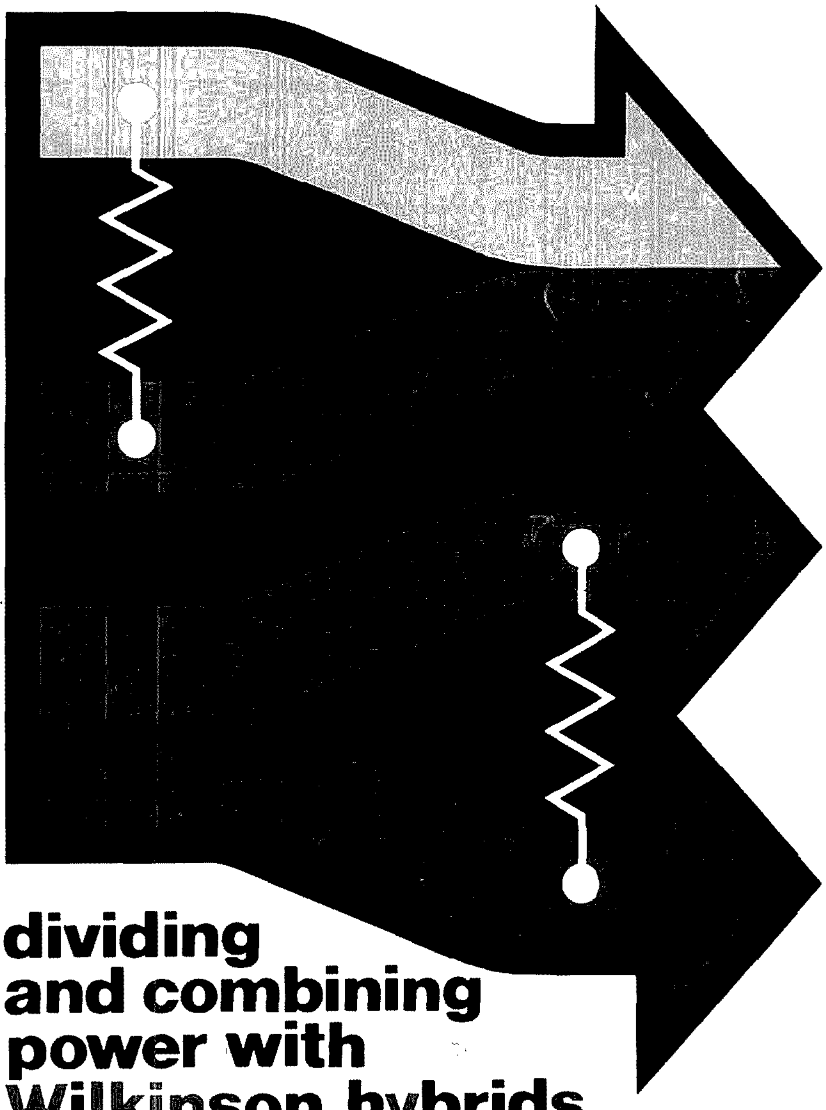
ham radio magazine

- blanking the Woodpecker
- Operation Upgrade Part 3
- 10-meter fm
- a 220/2-meter converter

hr

focus on communications technology



dividing and combining power with Wilkinson hybrids

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contents

Observation & Opinion

Short circuits. You've seen this column in *ham radio* from time to time and in other Amateur Radio magazines under a different heading. It all means the same thing: *errors*. Errors creep into articles almost regardless of how much care is used — in proofreading, editing, and preparing artwork. It's Murphy's law at work, something we all must live with.

We receive letters from readers who bring technical inaccuracies to our attention, and we appreciate such information. It helps keep us on our toes so that we can maintain the standard of excellence that *ham radio* has enjoyed for thirteen years. Keeping errors to a minimum, however, is really a joint effort between our editorial staff and our authors. I thought you might be interested to learn a bit about how that joint effort works.

When I review a submitted article for possible publication, the first things I look for are originality and interest to our readers. If the contribution meets these requirements, I next look for completeness and attention to detail. The article is then examined for obvious technical errors.

The errors that are not so obvious cause the real problems. A misplaced or mislabeled component on a schematic diagram can blow an entire project. Is it a 0.01-μF or a 0.1-μF capacitor? Is it an earth or chassis ground? Such seemingly minor errors have a way of being noticed at the last minute, generally when the magazine is about ready to go to the printer.

Our authors help us reduce the error count by carefully checking their copies of the typeset article. When it is at all possible, we ask that our authors ask a knowledgeable second party to go over the article and look for errors. I've seen cases where an error has been consistently overlooked by many people, only to appear in print despite careful inspection.

We sometimes get complaints from authors who say that a schematic prepared by our artist was not laid out in the same way the submitted version was. There is a very good reason for this. Because of page-size restrictions, drawings must sometimes be redrawn to fit the available space. In such cases the drawing must be checked by all concerned with special care to avoid omissions and circuit errors.

Another source of possible errors is math equations. Although we don't have a staff of mathematicians available to check manuscripts, we are able, in most cases, to track down errors and to locate any incomplete or inconsistent definitions of terms. We try to make our authors understand that we depend on them for unambiguous mathematical material. It's obvious, for example, that there's a difference between $\sqrt{2/2}$ and $\sqrt{2}/2$, yet such an error was found in the final page proofs of an article scheduled for one of our winter issues. In this case it was an error in typesetting — but an important one. Fortunately, with careful checking, we caught it.

We recognize the reader's disappointment when he has built a circuit only to discover it doesn't work because of an error in the article. When we learn that an error has gotten by us, we try to schedule a short circuit item in a timely manner, but it's not always possible to include the correction in the issue immediately following a published article. Sometimes a month or two go by before we even learn of an error. For this we ask your indulgence; the correction will appear just as soon as possible.

I've written this essay on short circuits to emphasize the fact that we are trying our utmost to produce a magazine of articles that will instill confidence in the reader. I have tried to explain some of the problems that, with careful attention to detail and our author's help, can be minimized. Our goal is no short circuits. We probably won't achieve perfection, but we intend to come very close. That's our New Year's resolution.

Alf Wilson, W6NIF
editor

comments

geostationary satellites

Dear HR:

I am writing to tell you that I enjoyed "Locating Geostationary Satellites" by Walter Pfiester, W2TQK, in the October, 1981, *ham radio*. I feel, however, that several minor additions would add to the utility of the program for those that might use it on repeated occasions. The addition of labels and a routine for entering data would save keystrokes and allow more rapid manipulation of data. For my own use, the modifications would be as follows:

step	key
000	LBL
001	A
002-068	As in existing listing
069	LBL
070	B
071	STO
072	00
073	R/S
074	LBL
075	C
076	STO
077	01
078	R/S
079	LBL
080	D
081	STO
082	02
083	R/S
084	LBL
085	E
086	CMS
087	FIX
088	3
089	R/S

The key codes were not included in my listing because the program was set up on a SR-52 and the key codes are not identical. The program would be recorded on a magnetic card for use with the SR-52 or TI-59 and used as follows:

(1) Read Card (SR-52 or TI-59 only, key in program for TI-58 or 58C)
(2) Initialize, Press E, Display reads 0.000
(3) Enter parameters in any order
 (a) Earth station latitude, Press B
 (b) Earth station longitude, Press C
 (c) Spacecraft longitude, Press D
(4) Find azimuth and elevation, press A (display azimuth), then press R/S to display elevation.

All other comments and notes are the same but a saving of six keystrokes is achieved.

Mac Mayercik, W2TI
High Bridge, New Jersey

Novice playgrounds

Dear HR:

I am in complete agreement with the views expressed in the October, 1981, editorial. In addition, I believe that the Novice bands have — on the whole — become more like playgrounds than training grounds ever since the FCC allowed *renewable* Novice tickets. But, be that as it may, higher-class hams should lend a helping hand to those Novices whose operating practices are conspicuous by their lack of know-how in proper procedures. A good place to begin is to advise Novices (and others, too) of the true meaning of "R."

Bill Morris, WA5MUF
Denton, Texas

best best regards regards

Dear HR:

The points in your "Observation and Opinion" in the October issue of *ham radio* were well taken. However I believe you did not go far enough. Beginners are not the only ones to use poor practices. Those of us who have been on the air for many years sometimes make the beginners sound good. A few examples:

73's..This is a double plural, as 73 means best regards. To wish someone best 73s means best best regards regards. Not very grammatical!

Phonetics: There are two generally accepted phonetic codes. One is the ITU phonetic alphabet; the other is usually called the phonetic code and is more popular. Some operators have been heard to mix the two, or use them alternately. The practice of using both the letters and the phonetics can be very confusing to the listener. Another poor practice is making up your own phonetics using names of cities or countries. This creates a false idea of where the station is located. But probably the most objectionable is the fugitive from the CB bands who is cute in choosing his own phonetics, such as "southern fried chicken" for SFC.

Proper operating habits can make this great hobby much more rewarding for all of us.

Howard B. Mouatt, W6BQD
Palm Desert, California

Hamvention slide show

Dear HR:

As a result of many requests from radio clubs for program material on the Hamvention, the Dayton Amateur Radio Association has developed an audio-visual slide show. The program runs for twelve minutes and is suitable for showing at club meetings. The show depicts one Amateur's activities at the three-day affair. It will give the first-timer an idea of what to expect, and will bring back many memories to the regular Hamvention visitor.

Use of the program is free, but a security deposit is required to ensure reasonable turn-around time.

For additional information write Hamvention Slide show, Box 44, Dayton, Ohio 45401.

Bob McKay, N8ADA
Editor, RF Carrier
Dayton Amateur Radio Assoc.

presstop

THE FCC'S AMATEUR RULES REWRITE has been killed. In an open FCC meeting on Thursday, November 12, the commissioners agreed unanimously to forego the controversial rewrite in view of the overwhelming opposition to PR Docket 80-279 by the Amateur community.

Most Of The Approximately 1400 who filed comments on the proposal opposed it. Many cited the question-and-answer format as being both irritating and unnecessary, along with their other objections to specific points or seeming omissions. Leading the opposition was the ARRL, which condemned the rewrite saying it would turn the Amateur service into a "sophisticated Citizens Band Service." The League joined with many others in criticizing the elimination of the present basis and purpose of Amateur Radio as well as the proposed renaming of the Service.

The Possibility Of A Future Rewrite by Amateurs themselves was left open by the Commission in its decision, which noted the FCC's rewrite effort should prove helpful in the event such a project is undertaken later.

Other FCC Actions Possible in the near future will likely concern the extension of SSTV and facsimile to all phone frequencies, and expansion of the present phone bands.

10 MHZ WON'T BE AVAILABLE to U.S. Amateurs when the WARC 79 provisions go into effect January 1, though Amateurs in a number of other countries will greet the new year on the new band. The British will be on 30 meters January 1, and for a while the Home Office had agreed to give them limited privileges on 18 and 24 MHz as well. However, that agreement has now been rescinded.

ARRL DIRECTOR ELECTIONS in two divisions have been declared null and void by the League's Executive Committee, and will be rerun. The two divisions are the Pacific, where the incumbent's statement exceeded the specified limits, and the Great Lakes, in which the incumbent's statement did not appear the way he had intended. Though initially the Executive Committee had decided to proceed with the election, its members decided in a later meeting that the League staff should have resolved the problem before the ballots went out so a new ballot was needed.

New Ballots Were Mailed to members in both divisions about December 1, with counting of the ballots scheduled to take place on January 20. The new ballots are for the directors election only; the Pacific Division vice director race will still be decided by the votes cast with the original ballots, while in the Great Lakes Division there was only a single candidate for vice director.

Duplicate Ballots have been mailed to all League members who reported nonreceipt of the original mailings, but in a number of cases (including the entire state of Hawaii) the original ballots did eventually show up after having been lost in the postal system for over three weeks. A few of those receiving two ballots have been found to have returned both, so now all ballots from the ZIP codes where duplicate ballots were sent are being checked to weed out any duplicated votes.

THREE NEW RUSSIAN AMATEUR SATELLITES could be launched at any moment, according to a number of European sources, possibly in a spectacular triple launch. All three are supposed to have Mode A transponders, plus a unique "robot" transponder that responds to an appropriate call by sending back the caller's callsign, a signal report, and possibly the serial number of the contact. The robot frequencies (in/out) are reported as 145.82/29.32, 145.83/29.33, and 145.84/29.34 respectively for the three birds. Transponder bandpasses start 40 kHz above the two robot frequencies.

OSCAR 9 (UoSAT) Checkouts continue well, with the CCO camera sending a test pattern over the weekend. Final satellite stabilization procedures are due to begin, after which the gravity gradient boom will be extended.

OSCAR 8 Is Also Working Well, though Mode A users are being bothered by both current strong ionospheric attenuation of the downlink signal and an increasing number of terrestrial stations operating in the 29.4-29.5 downlink passband. Two-meter simplex stations in the 145.85-146.00 passband are also bothering users.

AMATEUR RADIO'S FATE, insofar as the FCC is concerned, may rest with the forthcoming report of the Commission's "Program Evaluation Task Force." The task force, made up of FCC staff members, has been reviewing all commission activities to determine what programs could be cut back or eliminated. Such cutbacks would be alternatives to the 12 percent across-the-board cut that is presently planned. Either way, the Amateur community appears destined to lose out, particularly in exams and in enforcement. With FCC services certain to be cut, the provisions of Senator Goldwater's S.929 that would permit Amateurs to assist the FCC in exam administration and enforcement take on new importance.

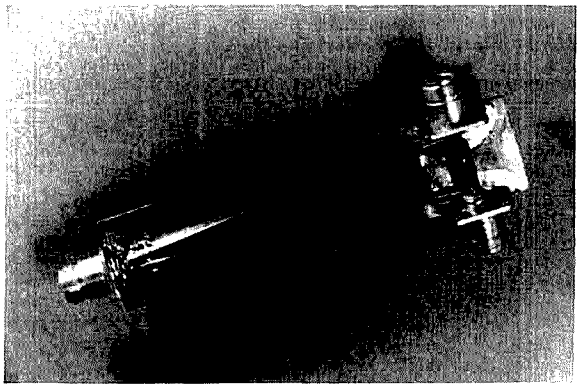
CANADIAN CUSTOMS EXEMPTIONS for Amateur equipment have just been extended to include equipment that is termed "primarily" for Amateur use. Previously, exemptions applied only to equipment solely for Amateur use, resulting in (for example) Amateur transceivers with general coverage receivers not receiving the exemption.

Solution for dividing or combining power using matching sections made of coaxial cable, lumped constants, and microstripline

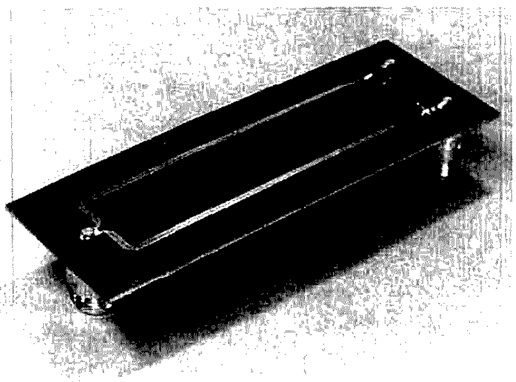
Wilkinson hybrids

Have you ever needed to divide power, or possibly combine power, at the same or at a different impedance? A device called the Wilkinson Hybrid[1,2,3] can do this and more. The beauty of this device lies in its ability to combine two inputs while providing high isolation between the ports over a wide bandwidth. It's simple to construct and almost lossless. The circuit can be constructed in at least three forms: lumped elements, coaxial lines, and microstrip. Often the Amateur wishes to build an amplifier with an output power level that exceeds the capability of a single device. Thus, the most common use of the Wilkinson Hybrid is to split equally exciter power feeding two transistors then recombine the output power at the antenna connector, **fig. 1**.

We will examine the Wilkinson Hybrid mainly at VHF and UHF. By doing this, we can decide the best form of quarter-wave impedance-matching device to use. We will see that the use of lumped constants at low frequencies will give way to coaxial structures that must also give way to microstrip as the frequency is increased. We will examine the agreement between experimental models and the theoretical predictions.



Wilkinson Hybrid using semi-rigid coaxial lines.



Wilkinson Hybrid using printed circuit board.

construction

The Wilkinson Hybrid shown in **fig. 2** is constructed with coaxial cable. The sum port serves either as the input connector for splitting power, or as the output port when used for combining the power at the side ports. Because the coaxial lines are connected together at the sum port, each coax line must pre-

By Ernie Franke, WA2EWT, 63 Hunting Lane, Goode, Virginia 24556

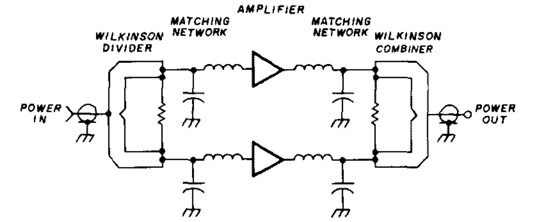


fig. 1. The Wilkinson Hybrid splits drive power then recombines the output power from the amplifiers.

sent a 100-ohm impedance, so that the parallel equivalent impedance will be 50 ohms. The other end of the coax must present 50 ohms at the side port. The characteristic impedance, Z_o, of a quarter-wave matching transmission line should be equal to the geometric mean of the end impedances:

$$Z_o = \sqrt{100 \times 50} = 70.7\ ohms \qquad (1)$$

If one wishes to transform a sum-port impedance of 50 ohms to an output-impedance of 25 ohms, for example, the line's characteristic impedance would then be:

$$Z_o = \sqrt{100 \times 25} = 50\ ohms \qquad (2)$$

(A handy value thanks to the ready availability of 50-ohm coax.)

A balance resistor is placed between the side ports. Its value is equal to twice the value of the side-port impedance. This resistor absorbs any unbalance in power levels or phase difference between the two side ports.

return loss

Let's digress for a moment and discuss another way of expressing standing wave ratio (SWR), known as return loss. Return loss, R, is the ratio of power in the incident (forward) wave to that in the reflected wave expressed in decibels:

$$R(dB) = 10 \log_{10} \frac{incident\ power}{reflected\ power} \qquad (3)$$

$$= 10 \log_{10} \frac{Pf}{Pr}$$

It has the same components as our old friend SWR:

$$SWR = \frac{1 + \sqrt{Pr/Pf}}{1 - \sqrt{Pr/Pf}} \qquad (4)$$

When you think about it, return loss is exactly what you measure, converted to dB, when you place a thru-line™ Bird wattmeter into the line. If a termination is very good, the return loss is high. If, however, the termination is totally reflective, such as an open or a short circuit, the return loss is zero. If a 3-dB attenuator is placed in front of the short circuit, the return loss is 6 dB. This loss occurs because the incident power receives an initial 3-dB loss in the pad, is totally reflected at the short circuit, and receives an additional 3-dB reduction before appearing as the reflected power back at the input.

input match

The input match of a Wilkinson is quite attractive: greater than 20 dB return loss (SWR ≤ 1.2:1), over any Amateur band. Even if one of the side ports is shorted or blows open (such as in the case of a catastrophic failure of a transistor), the input return loss will fall to only 6 dB (SWR = 3:1). This is easily seen as the round-trip (return) loss of a wave traveling in the shorted side of the hybrid. The wave receives the initial 3-dB power split, is totally reflected at the short circuit, and receives the additional 3-dB reduction going back on the quarter-wave line. This excellent input match helps to keep the driver amplifier from becoming detuned or unstable.

The input return loss for several forms of the Wilkinson Hybrid is shown in **fig. 3.** The widest bandwidth occurs when the quarter-wave line is 70.7 ohms. Return loss is also shown for 73-ohm (RG-59/U) and 75-ohm (RG-11/U) coaxial cable (because they are readily available). I have also shown the input match for a single- and a double-section lumped-constant hybrid. We can see from the graph that it's best to use coax or microstrip[4] with an impedance as close as possible to 70.7 ohms. But Amateurs will rarely notice the difference between RG-59 or 70-ohm semi-rigid coaxial cable.

Even though we look at the use of the Wilkinson at VHF, it performs just as well at lower frequencies. Dana Atchley[5] uses this technique at 80 meters to combine the power from several elements in a 360-

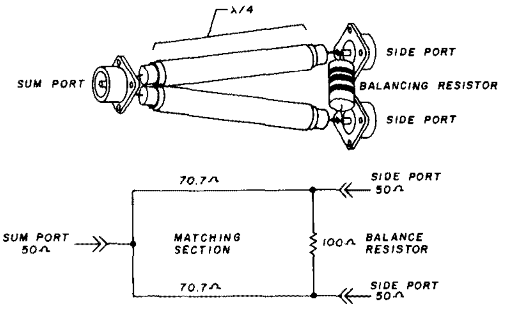


fig. 2. A Wilkinson Divider can be formed by two quarter-wave coaxial lines and a balancing resistor.

degree steerable vertical phased array. To determine how well the Wilkinson will perform at lower frequencies, merely multiply the center frequency of the band by the normalized frequencies at the bottom of each graph.

isolation

If one connects two transistors in parallel to double the available power, problems usually develop. The input and output resistance will be halved, while the shunts reactance will be doubled. This situation will decrease bandwidth, increase temperature sensitivity, and decrease stability. If one transistor has a slightly higher current gain, a phenomenon known as "power hogging" will occur: this is an unstable condition wherein there is uneven load-sharing, and one transistor tries to accept all the available drive.

With a Wilkinson Hybrid *isolation* is obtained between the side ports. Therefore, if the impedance of either transistor fed by the hybrid is slightly different, or if the impedance changes with drive, no change occurs at the other port. Even if one transistor fails, the other transistor will hardly notice the added load.

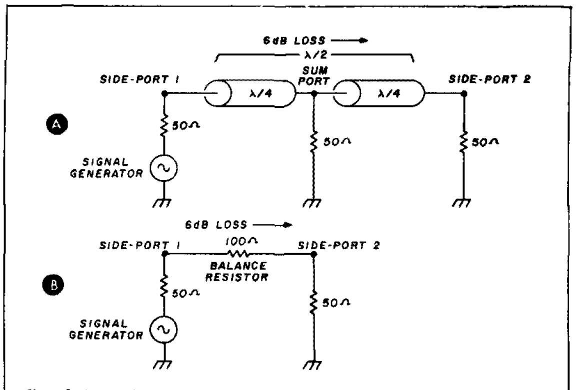


fig. 4. Loss in quarter-wave-line path, A, is equal to the loss in the balancing resistor path, B.

Isolation, being a loss between the side ports, is measured by applying power to one of the side ports and detecting the power at the other port (assuming the sum port is properly terminated). A signal from one side port travels in two directions. The signal traveling toward the sum port, fig. **4A**, undergoes a 6-dB loss before appearing at the other side port. The path through the balance resistor, fig. **4B**, also undergoes a 6-dB reduction. Thus the two paths recombine with equal amplitude; however, the cable path is one-half wavelength, or 180 degrees, longer than the resistor path. Thus the power from one side port is completely cancelled at the other port.

If the sum port is not terminated properly, the isolation will be degraded. A signal from one side port travels toward the sum port, receiving a 3-dB loss. It then encounters the return loss of the sum port termination before receiving an additional 3-dB loss going to the other side port. Therefore, the isolation, I, due to a mismatch at the sum port is:

$$I = T_s + 2D \tag{5}$$

Where T_s is the return loss of the sum termination, and D is the power division of the hybrid (3 dB). If the return loss of the termination placed at the sum port is 20 dB ($SWR \leq 1.2{:}1$), the side port isolation will be 26 dB.

The isolation over the Amateur bands, fig. **3**, should be greater than 30 dB. If one side port is badly terminated, the reflected power will be 30 dB down at the opposite side port.

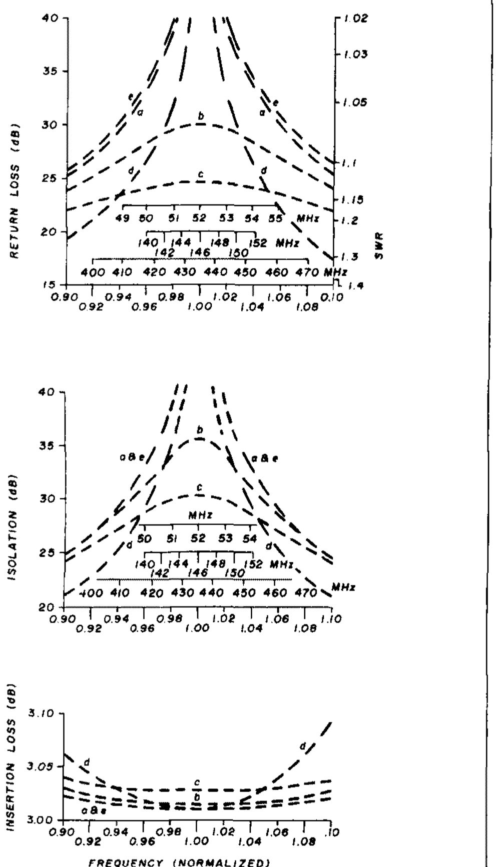


fig. 3. Theoretical return loss, isolation, and insertion loss with matching sections: curve a: 70-ohm lines; b: 73-ohm lines; c: 75-ohm lines; d: single-section lumped constants; e: double-section lumped constants.

insertion loss

The insertion loss of a Wilkinson Hybrid should be

3.01 dB, with one-half the power arriving at each side port. Any difference in power is either absorbed by lossy dielectric, reflected to the sum port, or absorbed in the equalizing resistor. The insertion loss of a Wilkinson should be less than 3.1 dB throughout the band, which represents a loss of only 0.1 dB. The insertion loss increases only slightly, fig. 3, when the quarter-wave line departs from the ideal value of 70.7 ohms.

experimental models

Several models were constructed to verify the predictions of **fig. 3**. The physical length of a quarter-wave transmission line, $\lambda g/4$, is given by:

$$\lambda g/4 = \left(\frac{C}{f}\right)\left(V_f\right)\left(\frac{1}{4}\right) \qquad \textbf{(6)}$$

where C is the speed of light (2.998 × 10^{10} cm/sec-

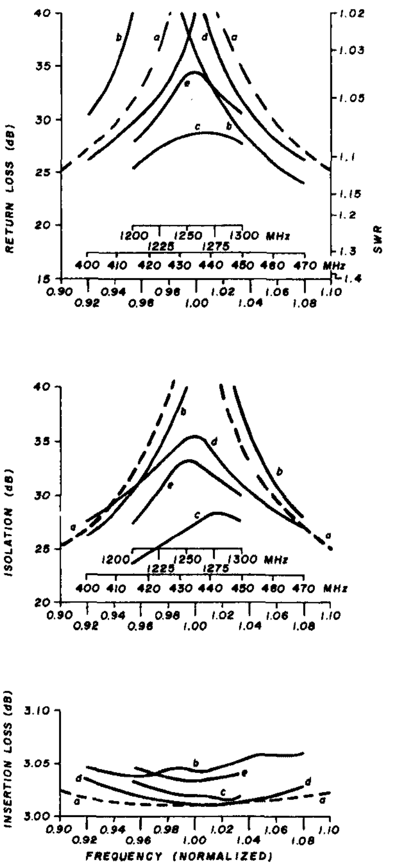


fig. 5. Performance of a Wilkinson Divider using 70-ohm quarter-wave lines: curve a: theoretical; b: 70-ohm semi-rigid lines at 432 MHz; c: 70-ohm semi-rigid lines at 1296 MHz; d: 70-ohm microstrip at 432 MHz; e: 70-ohm microstrip at 1296 MHz.

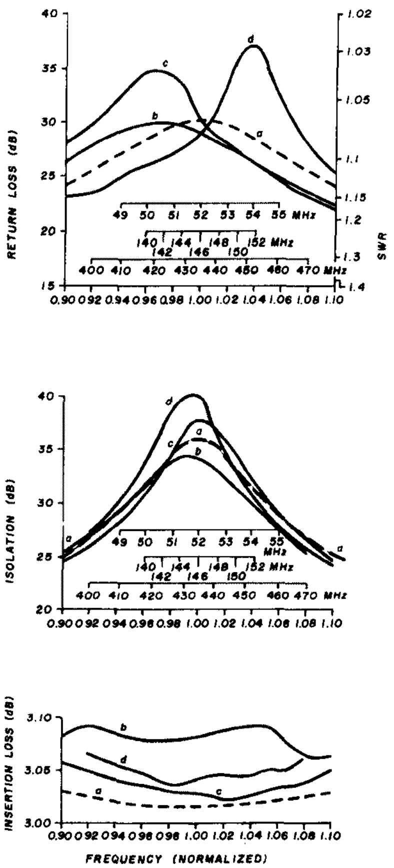


fig. 6. Performance of a Wilkinson Divider using RG-59/U (73-ohm) coax: curve a: theoretical; b: 50 MHz; c: 144 MHz; d: 432 MHz.

ond), f is frequency in hertz, and V_f is the velocity factor. The velocity factor for several materials is given in **table 1** with the physical length of a quarter-wave section in centimeters. This data is useful for constructing either coaxial or microstrip transmission-line models. The 1/16-inch (1.6-mm) thick glass epoxy (G10) and Teflon-fiberglass printed wiring board is double-clad with 1 ounce of copper. The width of a 70.7-ohm line for the G10 board is 53 mils (1.4 mm) and 94 mils (2.4 mm) for Teflon-fiberglass.

The results using 70-ohm semi-rigid coaxial lines and printed microstrip quarter-wave lines are shown in **fig. 5**. The agreement is quite good at 432 MHz and 1296 MHz. Next, I tried using RG-59 coax to determine what effect a variation in line impedance might produce, **fig. 6**. I was able to achieve a return loss of better than 25 dB, isolation better than 30 dB, and an insertion loss lower than 3.1 dB over the 6-meter, 2-meter, and 75-cm bands. This speaks well for using readily available 73-ohm coaxial cable.

lumped constants

A quarter-wave matching section may be synthesized from lumped constants using a pi model according to **fig. 7A**. Because the quarter-wave sections are paralleled at the 50-ohm summation port, each section must present a 100-ohm input impedance, **fig. 7B**. The other end of the quarter-wave section will equal the side-port impedance of 50 ohms. Substituting a value of 90 degrees for B we see that $Z_a = Z_b = -j70.7$ and $Z_c = +j70.7$. We can thus solve for the component values by simply inserting the proper operating frequency, f, into these formulas:

$$L = \frac{Z_C}{2\pi f} = \frac{70.7}{2\pi f} \; henries \qquad \textbf{(7)}$$

table 1. Velocity factor for several dielectric materials and physical length of a quarter-wave section.

material	velocity factor V_f	52	146	222	435	1296
		frequency (MHz) quarter-wave line length, cm (inches)				
solid poly RG11, 59r	0.66	95.0 (37.4)	33.8 (13.3)	22.3 (8.8)	11.3 (4.45)	3.8 (1.5)
foam poly	0.80	115.3 (45.4)	41.1 (16.2)	27.0 (10.6)	13.8 (5.4)	4.6 (1.8)
solid Teflon	0.69	100.0 (39.4)	35.6 (14.0)	23.3 (9.2)	12.0 (4.7)	4.0 (1.6)
glass epoxy (E = 4.8)	0.54	77.8 (30.6)	27.7 (10.9)	18.2 (7.2)	9.3 (3.7)	3.1 (1.2)
Teflon (E = 2.55)	0.70	100.9 (39.7)	35.9 (14.1)	23.6 (9.3)	12.1 (4.8)	4.1 (1.6)

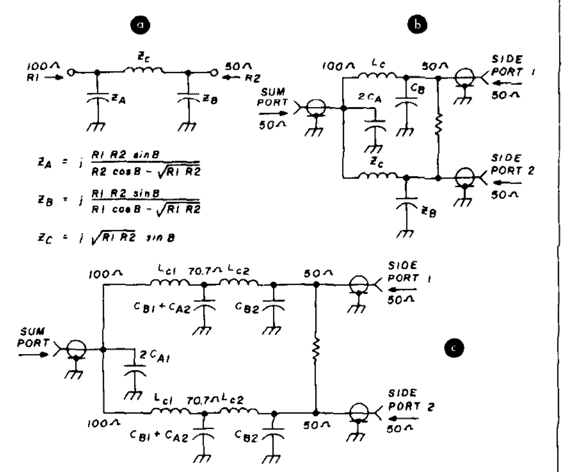


fig. 7. A pi section of lumped constants, A, forms the quarter-wave section in a single-section Wilkinson Hybrid, B, and eighth-wave matching sections in a double-section Wilkinson Hybrid, C.

$$C = \frac{1}{Z_A 2\pi f} = \frac{1}{(70.7)(2\pi f)} \; farads \qquad \textbf{(8)}$$

If we want a wider bandwidth device, we must divide the quarter-wave section into smaller, eighth-wavelength segments, **fig. 7C**. The intermediate impedance between the eighth-wavelength sections is equal to the geometric mean, 70.7 ohms, of 100 ohms and 50 ohms.

Using the equations in **fig. 7A** for $R1 = 100\ ohms$, $R2 = 70.7\ ohms$, $B = 45\ degrees$, we find, for the first pi section:

$$Z_{A1} = -j147\ ohms$$
$$Z_{B1} = -j374\ ohms$$
$$Z_{C1} = j59.5\ ohms$$

For the second pi section, where $R1 = 70.7\ ohms$, $R2 = 50\ ohms$, and $B = 45\ degrees$:

$$Z_{A2} = -j104\ ohms$$
$$Z_{B2} = -j264\ ohms$$
$$Z_{C2} = j42.0\ ohms$$

The results of several experimental models are shown in **fig. 8**. The capacitors were fixed values. The coils were adjusted to resonance using a grid-dip meter after shorting the side ports to ground and leaving the sum port open. This arrangement formed a one-half-wave tank circuit. With a single-section hybrid, the input return loss is better than 25 dB, the isolation better than 25 dB, and the insertion loss less than 3.1 dB over the 6- and 2-meter bands. The two-section lumped-constant Wilkinson did even better but was more difficult to adjust for resonance and symmetry.

amplitude and phase unbalance

When a Wilkinson Hybrid is used as a power splitter, each *side-port output will* have equal amplitude and phase, provided the ports are reasonably terminated. When the Wilkinson is used to combine the output *power* from two transistor amplifiers, the input power delivered to the two side ports may not be equal or in phase. This may be due to differences in *transistor gain and internal phase* shift. The power at the sum port will then be less than the sum of the two input powers. The percentage difference from this ideal sum of the two powers is given by:

$$n = \left(0.5 + \frac{\sqrt{r}\cos\theta}{r+1}\right) \times 100\,percent \qquad \textbf{(9)}$$

where n is the output power, r is the power ratio of the two input powers, and θ is the phase angle between them. If the two input signals are in phase but differ in amplitude, the **eq. 9** reduces to:

$$n = \left(0.5 + \frac{\sqrt{r}}{4+1}\right) \times 100\,percent, \qquad \textbf{fig. 9A (10)}$$

Thus we can see that, even for an input power ratio of 2:1 (3 dB), the output power will be down only 0.13 dB, or we will have 97 percent of the sum of the two input powers. If the amplitudes are balanced, but the phase of the two input power differs, then,

$$n = \left(0.5 + \frac{\cos\theta}{2}\right) \times 100\,percent, \quad \textbf{fig. 9B} \quad \textbf{(11)}$$

Thus we can see that, for an input phase difference of even ± 15 degrees, the output power will be down just 0.07 dB, or we will have 98 percent of the available power. For a combination of a power unbalance of 2:1 and a phase unbalance of ± 15 degrees, we would suffer a total loss of only 0.2 dB, leaving 96 percent of the original power.

balance resistor

If the power or phase relationships are not equal in the side ports, a voltage will appear across the balance resistor. If one transistor should fail completely, one-fourth of the normal total sum port power would be absorbed by R1. This is the same as saying that one-half of the power is available after losing one amplifier.

Under typical conditions, the power will be balanced to within 2:1, and the phase will be within 15 degrees. This condition represents a maximum power reduction of 0.2 dB. One-half of the power will be absorbed in a balance resistor. When combining the outputs of two 50-watt transistors, 1.5 watts will be dissipated in the balance resistor.

The use of a 2-watt carbon balance resistor (with nearly zero lead length) was compared with the use of a stripline resistor at 432 MHz. Only when the re-

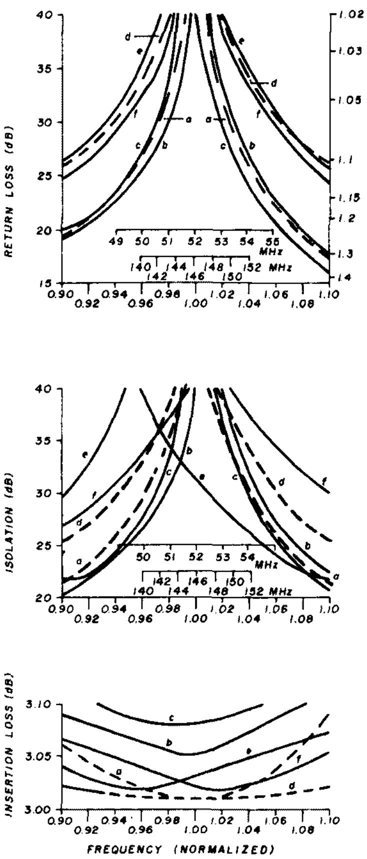


fig. 8. Performance of a Wilkinson Divider using lumped constants: curve a: theoretical; b: 50-MHz single section; c: 144-MHz single section; d: theoretical double section; e: 50-MHz double section; f: 144 MHz double section.

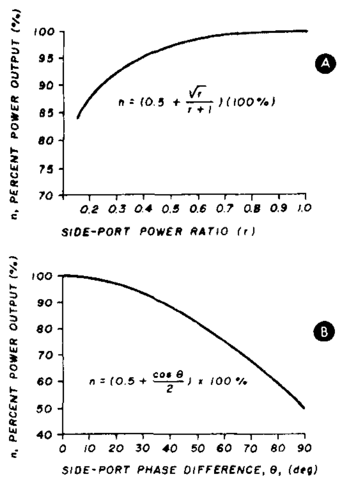


fig. 9. Percentage output power remains at greater than 97 percent of the sum of the two inputs, A, for side port power ratios to 2:1. The power output remains greater than 97 percent, B, for phase differences ± 20 degrees.

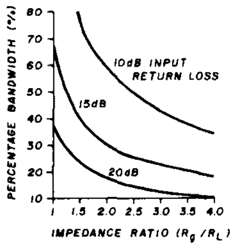
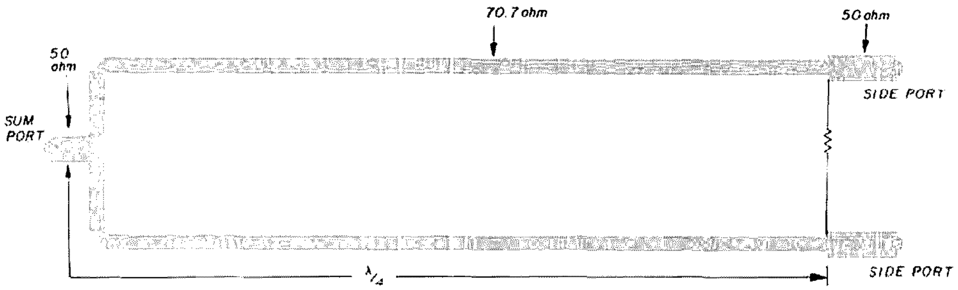
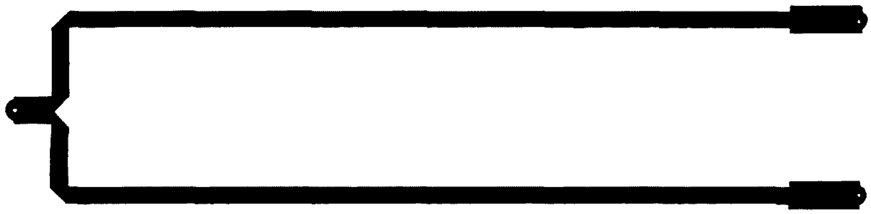


fig. 10. Percentage bandwidth decreases as the impedance transformation of a Wilkinson Divider increases.





PC-board layout for the Wilkinson Hybrid.

turn loss or isolation exceeded 40 dB did any difference appear. Thus, the need of a stripline resistor is mainly for combining high-power loads.

input/output impedances

We have chosen to use 50-ohm input/output impedances because of the measurement simplicity for verifying input impedance, insertion loss, and isolation. Often the Amateur must transform the 50-ohm input impedance of an amplifier under construction to an intermediate value of, say, 12.5 ohms. Antenna combiners also often combine the power from two elements into a 50-ohm output. The experimental results coincided so well with the predicted values that *one can feel confident in a design incoporating an* impedance transformation whose performance is not as easily verified using standard test equipment.

The percentage bandwidth is:

$$\frac{(f\,high - f\,low)}{f\,center} \times 100\,percent \qquad (12)$$

However, it decreases with an increase in impedance transformation ratio, **fig. 10**. For an impedance ratio of 4 (50 to 12.5 ohms), the percentage bandwidth decreased from 37 to 10 percent while maintaining an input return loss of better than 20 dB ($VSWR \leq 1.2{:}1$).

conclusion

We have examined several media for use as quarter-wave matching sections in the Wilkinson Hybrid. For low-frequency operation, where the length of coaxial cable would be bulky, lumped elements might be the best choice. By using RG-59 coaxial cable (73-ohm impedance), the circuit departs only slightly from optimum performance. Coaxial cable is usually replaced by microstrip at 432 MHz and 1297 MHz.

We have compared the experimental models with theory and have shown good agreement. The designer should feel confident to simply calculate the physical length of coax and expect a return loss of more than 20 dB, an insertion loss of less than 3.1 dB, and an isolation of more than 25 dB.

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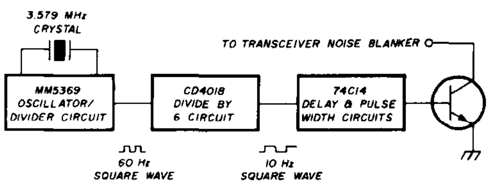
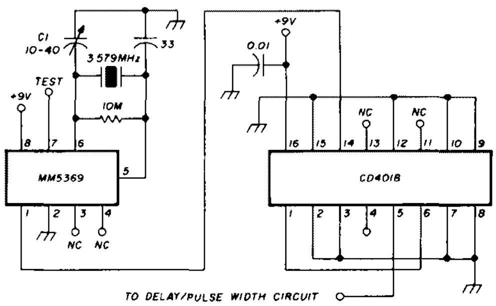


fig. 1. Block diagram of a synchronous noise blanker circuit. (See appendix for notes on devices.)



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.
k = 1,000 M = 1,000,000

fig. 2. Oscillator/divider circuit.

broadened by the narrow selectivity stages. The circuit is designed to be connected into transceiver noise blankers of the type that operate by reverse biasing diodes in a series gate. The circuit should operate without changes on the TS-520, TS-820 and earlier models on the ICOM 701, and any rigs using similar blanker circuits, with minimal modifications to the rig. It has been used to good effect on my ICOM 701 for several months.

how it works

A block diagram of the circuit is shown in **fig. 1.** An MM5369 oscillator/divider integrated circuit, of the type used in many quartz clocks, together with a 3.579-MHz color TV crystal is used to generate an accurate 60-Hz square wave (reference 1). This signal is digitally divided by six by the CD4018 CMOS IC, resulting in a crystal-locked 10-Hz square wave. This 10-Hz signal is processed through a series of inverting CMOS Schmitt triggers (all contained in one 74C14 IC), the details of which are described below. The output of these stages is used to turn a transistor off and on. It is the collector of this transistor that is connected to the transceiver noise blanker, upon which it imposes a 10-Hz blanking pulse. The circuit diagram for the oscillator/divider stage is given in **fig. 2.**

delay and pulse-width circuits

To understand the workings of the 74C14 circuit, which forms the essence of this blanker, it is necessary to delve briefly into the arcane digital world of CMOS. Many Amateurs seem to have a fear of digital circuits and prefer to stick with good old analog tubes and transistors. There is really no good reason for this, as in many ways digital circuits are more predictable than analog ones. For those with no experience in CMOS, the *CMOS Cookbook* by Don Lancaster (reference 2) is a very good introduction. The operation of the 74C14 circuit is described in Chapter 4 of that book, and divide-by-six circuit in Chapter 6.

The easiest way to understand how the 74C14 circuit works is to look at what needs to be done to blank the Woodpecker. As described in the previous article, the object of this circuit is to provide a blanker control signal that is exactly synchronized with the Woodpecker. It should turn off the blanker gate only while the Woodpecker pulse is present, leaving the rest of the time between pulses for the desired signal to come through.

Thus we need a variable delay circuit to allow us to synchronize the blanking with the Woodpecker, and a means of varying the output pulse so that it blanks for no longer than necessary. It turns out that both these functions can be served by the same type of circuit, which Lancaster refers to as the "half monostable."

Consider the circuit in **fig. 3.** If a square wave is fed to the input, and the RC time constant is much shorter than the period of the square wave, the RC circuit differentiates; that is, it gives a positive spike when the input goes up, and a negative spike when the input goes down. As some CMOS circuits don't like negative input voltages, a diode is used to short out the negative spike. If this positive pulse is fed to a Schmitt trigger circuit (CMOS or otherwise) the output will be a narrow positive pulse, in synchronization with the rising edge of the input square wave.

If the RC time constant of the circuit is about the same as the period of the input square wave, however, the output is going to look like a sagged square wave; that is, the dc level does not decay very much

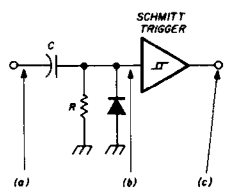


fig. 3. Half-monostable circuit.

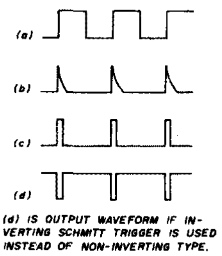


fig. 4. Waveforms for circuit in fig. 3.

before the square wave goes down again. Again, the diode cuts off the negative part of the wave. The waveforms are shown in **fig. 4**.

If this type of decaying square wave is fed to a Schmitt trigger, the output is a much broader pulse whose width is set by the point where the decaying voltage goes below the triggering level. As before, the beginning of the Schmitt output pulse is synchronized with the rising edge of the input square wave. Now if we make the resistor R a potentiometer, the RC time constant can be varied, and thus the width of the output pulse from the Schmitt trigger can be varied. It is most important to understand this, as the whole functioning of the synchronous blanker depends on this operation.

If you look up the specification sheet for the 74C14 in reference 1, you will notice that it contains six separate inverting Schmitt trigger circuits. Two points arise from this. The first is to point out the economy of using CMOS — only one IC is needed — and the second is that the output from an inverting Schmitt trigger is the inverse of an ordinary one. Thus, in a circuit such as **fig. 3**, the output of the inverting Schmitt trigger is positive all the time except for a brief drop to zero volts at the rising edge of the input square wave.

Okay, that should provide enough background to look at how the whole delay/pulse width circuit works. The circuit diagram for the delay and pulse width circuits is given in **fig. 5**.

The first stage in the delay/width circuit is a half-monostable (that is, as in **fig. 3**) using an inverting Schmitt trigger and a very short RC time constant (0.2 millisecond). The output from this stage is a brief negative-going spike synchronized with the rising edge of the input 10-Hz square wave.

The next stage is a half-monostable with a longer, variable RC time constant. The input to this is a square wave with a very high mark-to-space ratio; that is, almost all mark and no space. This waveform decays in the same way as described above, and the output from the inverting Schmitt trigger is a negative-going pulse whose width is variable from nearly zero to 0.1 second. The start of this pulse is also synchronized with the rising edge of the 10-Hz square wave input to stage 1.

Stage 3 is similar to stage 1: a half-monostable with a short, fixed RC time constant (0.2 millisecond). As before, the output is always positive except for a short drop to zero at the rising edge of the output from stage 2. Note now, however, that the output from stage 3 is synchronized not with the input to stage 1, but with the point where the decaying wave-

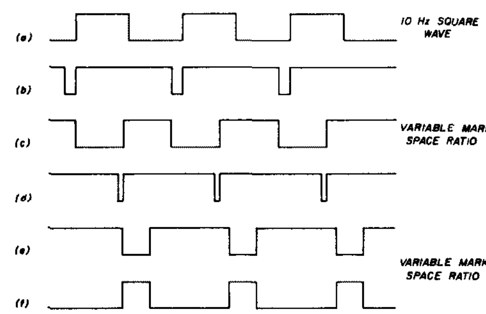


fig. 6. Waveforms for circuit in fig. 5.

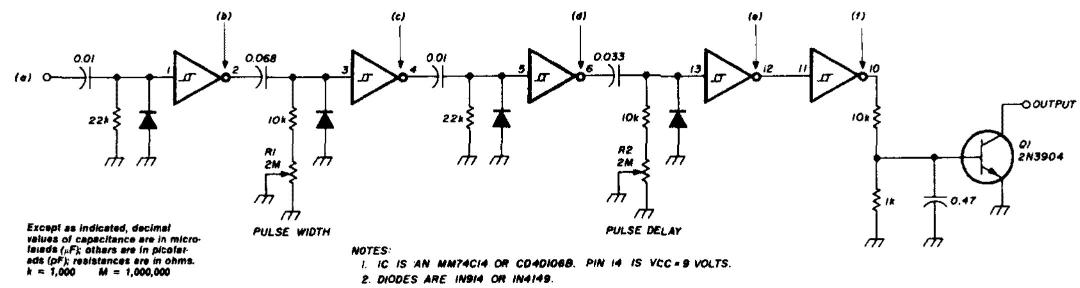


fig. 5. Delay and pulse-width circuits. Each device should be bypassed with a 0.01 μF ceramic capacitor with short leads.

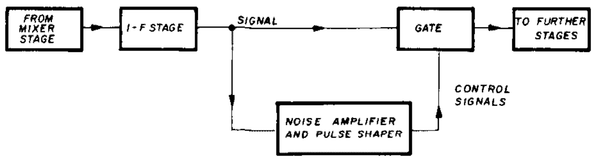


fig. 1. Block diagram of a conventional noise blanker.

been shown conclusive that this works, and any apparent success probably results from the Woodpecker's intrinsic inclination to move frequency of its own accord. One thing is certain, however, and that is that the dits make the interference even worse.

To understand why the majority of existing noise blankers are not too effective in silencing the Woodpecker, one must consider the type of noise that they were designed to blank. In nearly all cases, this is car ignition type noise: typically of high amplitude and of short duration (that is, 0.5 milliseconds or less). The blankers work in the following way: early in the i-f stage of the receiver, usually before narrow selectivity is introduced, the noise pulse is detected through a noise amplifier that selects only high-amplitude signals with rapid rise times coming from the mixer stages. The amplified noise pulse is shaped into a control signal that is used to turn off a gate of some sort — usually by means of reverse-biasing diodes through which the signal has to travel to proceed further into the receiver. Thus the receiver is turned off temporarily, for the duration of the noise pulse.

In a well-designed blanker, the noise pulse is cut off almost as soon as it begins. The receiver is turned off for only a short time, and, unless the noise pulses are very frequent, the net effect is virtually inaudible as far as the desired signal is concerned. A block diagram of the circuit is shown in **fig. 1**.

The Woodpecker, on the other hand, consists of pulses of fairly long duration — typically 15 milliseconds — which do not have a particularly fast rise time, and which are composed of a range of spikes of variable amplitude. While most noise blankers do chop some of the Woodpecker pulse, this is usually nowhere near enough to give effective blanking. (You can see the blanker working if you connect an oscilloscope to the gate.) The main problem with conventional noise blankers is that when it is horrendously strong, the Woodpecker signal is not sufficiently different from desired signals in ways that the blanker can distinguish.

What is probably one of the best conventional blanker circuits designed to silence the Woodpecker was published in *ham radio* by Ulrich L. Rohde, DJ2LR, in June 1980.[3] It is claimed to be effective against the Woodpecker, by dint of a very high-gain noise amplifier. However, the circuit is quite complex and requires significant modification to existing receiver circuitry.

another way

If conventional noise blankers are limited in their ability to deal with the Woodpecker, what alternative approaches are available? To answer this, it is best to look again at the characteristics of the Woodpecker itself. There are three principal characteristics which distinguish it from desired signals:

1. The transmission consists of intense, evenly placed pulses.
2. The transmission bandwidth is wide — usually 50 kHz.
3. The pulse repetition frequency is constant, and a very precise frequency.

The first two of these characteristics have been noted in earlier articles on the Woodpecker. The Rohde circuit makes use of the first of the characteristics to generate a blanking signal in the conventional way.

What does not appear to have been noticed before is the stability of the PRF of the Woodpecker. This is usually exactly 10.000 Hz — to an accuracy of at least 1 part in 100,000 on the night I measured it. Other PRFs are used from time to time, particularly 16 Hz, and sometimes 20 and 32 Hz. There may be others as well. However, all of them have one thing in common: they are extraordinarily precise.

This discovery leads to a completely new approach to silencing the Woodpecker: the synchronous blanker. The concept of the synchronous noise blanker is not new: M.J. Salvati[4] proposed in 1974 a circuit to blank power-line interference spikes, using a control signal derived from the line voltage itself. Taken one step further this idea can be used on the Woodpecker. In the circuits to be discussed in this and the following articles, a crystal-locked 10-Hz (or 16-Hz, etc.) signal is generated (quite separately from the Woodpecker). This signal is then phase shifted to synchronize it with the incoming Woodpecker pulses; it is this signal that is used to blank a noise gate to silence the Woodpecker.

The circuit is shown in general terms in the block diagram of **fig. 2**. It works as follows: The output of a high-frequency crystal oscillator is divided down

fig. 2. Block diagram of a synchronous noise blanker circuit.

digitally to give a 10-Hz crystal-locked waveform. This signal is fed to a digital delay circuit, then to a circuit that generates an output pulse of variable width. This pulse is used to control a noise gate in the conventional manner.

In operation, the delay circuit is adjusted manually to synchronize it with the offending Woodpecker pulses. The blanking control pulse width is set so that *it is just sufficient to mute* the receiver for the duration of the Woodpecker pulse. As the Woodpecker stays in synchronization with the control pulse, there is no need to alter the sync control once set, unless another Woodpecker comes on that is out of sync with the first. Similarly, the width control does not need to be adjusted under the same circumstances.

It must be mentioned that this circuit is not perfect. Part of the trouble stems from the fact that the Woodpecker pulses are quite long compared with normal noise pulses, and when they are blanked out, one can hear the "gaps." Mostly this is not objectionable, however. The only real problem occurs when the Woodpecker pulses are long and "shaggy." Under these circumstances, one has to cut out too much of the desired signal for it to be readable. Readability starts to deteriorate noticeably when 25 percent of the audio is blanked. But under these circumstances nothing can help!

Fortunately, when the Woodpecker is at its worst, the pulse width is often quite narrow, and a synchronous blanker is very effective. On occasions, it can reduce the interference from S-9 + 20 to SØ (yes, zero).

In the following articles, two forms of a synchronous blanker will be described. The first can be attached to most existing transceiver noise blankers, with the blanking signal used to control the existing gate.

The second form of blanker to be described was designed for transceivers and receivers with no existing or suitable blanking circuitry. In this case the blanker plugs into the headphone output of the rig, and requires no tinkering with the rig's innards. With the second circuit, of course, no blanking is done in the i-f stages, and consequently the Woodpecker is still capable of swamping the AGC. Despite this shortcoming the circuit is quite effective.

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ham radio

2-meter transverter

Add a new band to your high-frequency transceiver with this hybrid circuit

The easy way for the owner of a high-frequency transceiver to get on VHF SSB is with a transmitting converter, or *transverter*. The essentials of a typical VHF transverter are shown in **fig.1**. A common heterodyne oscillator is used for both up conversion of the transmit signal and down conversion of the received signal. The 10-meter band is the customary intermediate frequency as it provides the widest tuning range on most transceivers, and its relatively high frequency favors good image rejection. A 2-meter transverter requires a local oscillator at 116 MHz to transform 28-30 MHz to 144-146 MHz.

In the block diagram I assume that the transceiver has a separate low-power output port from its driver or exciter. If this has not been provided by the manufacturer, it's usually a simple matter to so modify the transceiver. It's also advisable to add a switch that will remove heater voltage or supply voltage from the transceiver final amplifier when the transceiver is used with a transverter.

tubes versus transistors

The 2-meter transverter described here is a hybrid, which employs both tubes and transistors. It might be argued that tubes are now obsolete for all except high-power applications, but for Amateur work tubes have one important virtue: they're tough. Tubes are very forgiving of mistakes. A wiring error or accidental voltage transient can wipe out a transistor in less than a millisecond, whereas tubes will survive extreme overloads for a matter of minutes — plenty of time to locate a fault and correct it before the tube is destroyed. This is not so important where tubes can be replaced with inexpensive transistors, but VHF power devices are still far from inexpensive.

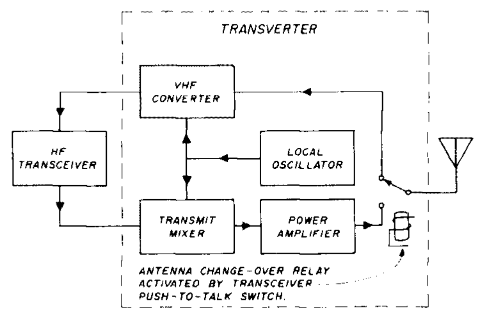

fig. 1. A transverter uses a common local oscillator to provide both up and down frequency conversion to the desired VHF band. Good linearity must be maintained in both transmitter mixer and power amplifier to ensure an undistorted transmitted signal.

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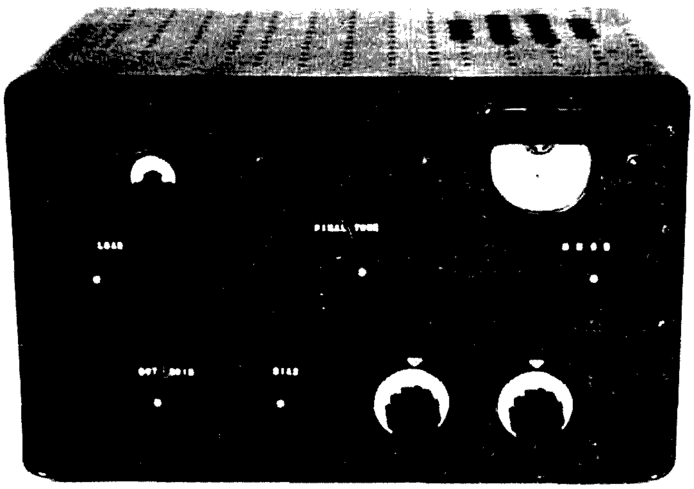
local oscillator

The heart of the transverter is the LO, and this circuit should be constructed first. A transverter local oscillator must supply considerably more rf power than a VHF converter LO, since a transmitting mixer typically requires an injection level of a few hundred milliwatts. In this 2-meter transverter, the LO, or heterodyne oscillator, constitutes a small, solid-state, 116-MHz exciter with a power output of about 1/8 watt.

Fig. 2 shows the LO circuit. The 58-MHz crystal oscillator, *Q1*, drives a push-push doubler, *Q2* and *Q3*, which doubles to 116 MHz and drives *Q4*, a class-C power amplifier. Feedback for *Q1* must pass through the series-tuned circuit, *L3-C1*. This high *L:C* ratio circuit resonates at 58 MHz and prevents the third-overtone crystal from oscillating on its fun-



The cabinet is 8.5 inches high by 13 inches long by 9 inches deep (21.6 by 33 by 23 cm). Meter at left reads either rf output voltage or PA grid current. The two flanged knobs at lower right are for adjustment of C4 and C5.

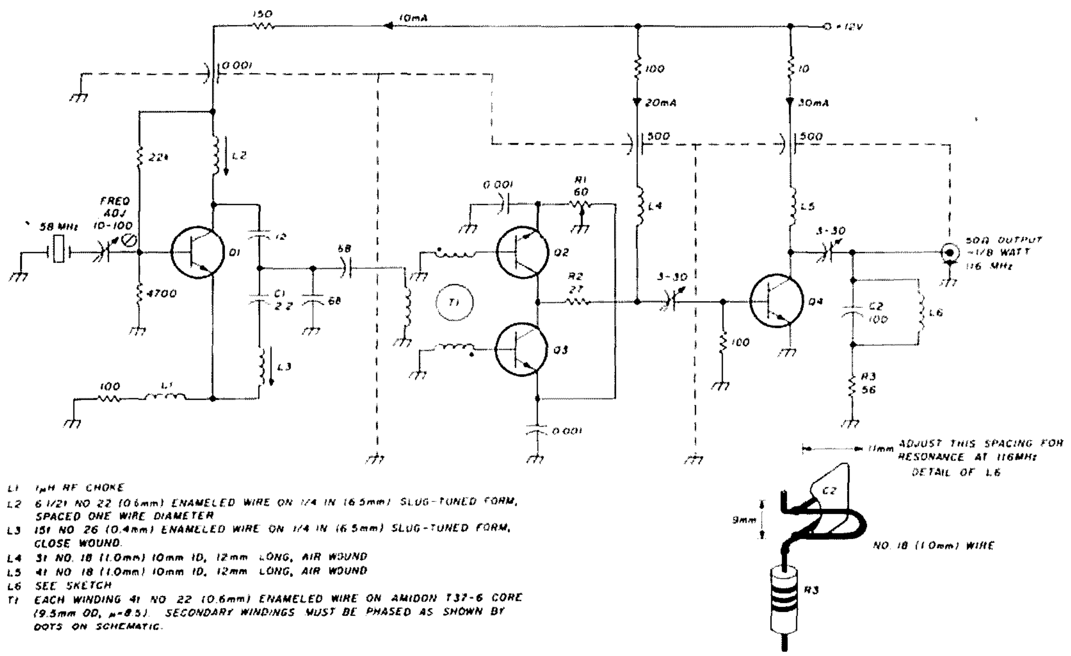


fig. 2. The heterodyne oscillator uses four transistors. Q1 is a 2N2222A, Q2 and Q3 are 2N2369As, and Q4 is a 2N5109. All variable capacitors are mica compression trimmers.

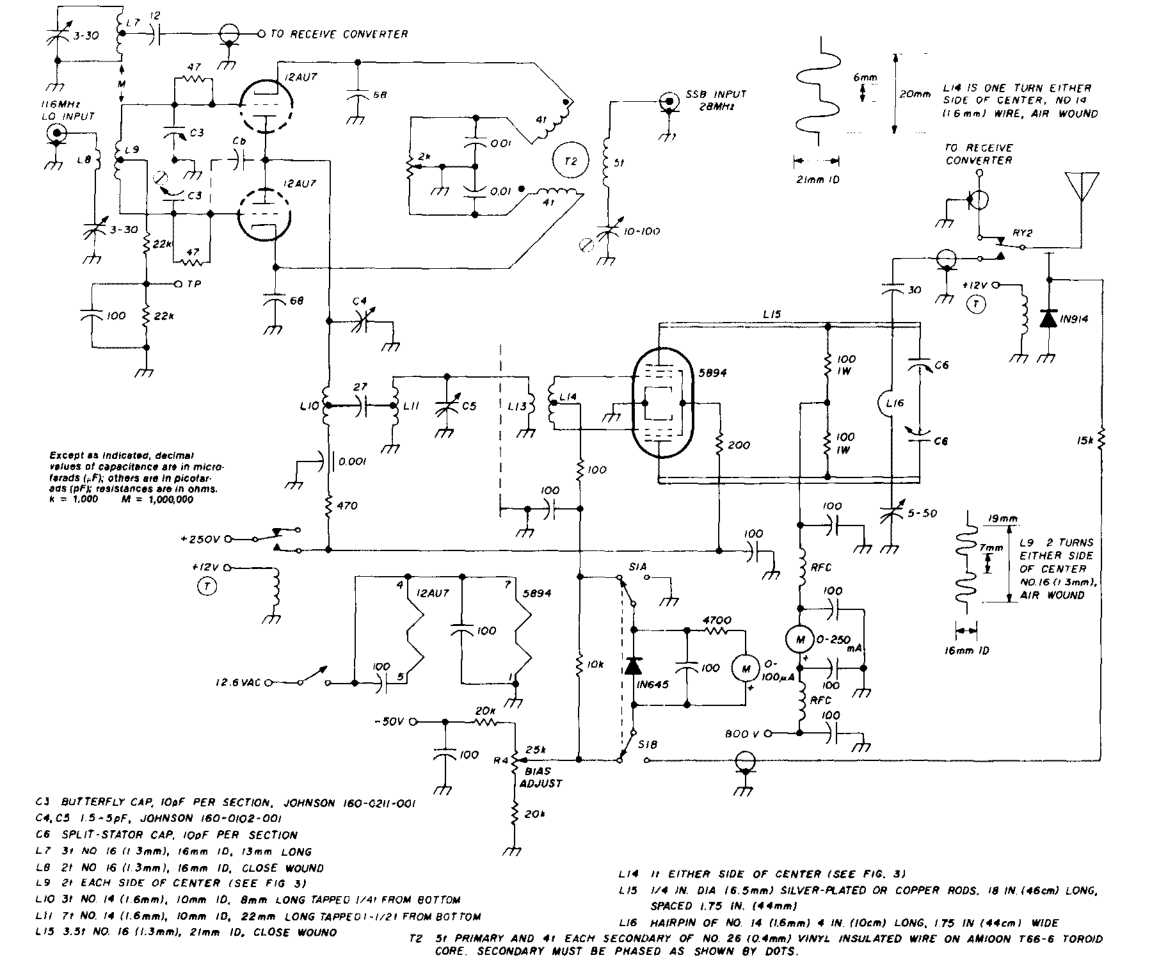


fig. 3. Transmit mixer and final amplifier. Relays RY1 and RY2 are actuated by the transceiver push-to-talk switch. The 3-30 pF capacitors connected to L7 and L8 are mica compression trimmers. The 47-ohm parasitic suppressors connected to the 12AU7 grids are 1/4-watt resistors shunting 3/4 inch (19 mm) of the No. 22 (0.6 mm) wire that connects C3 to the 12AU7 grid pins. Balancing capacitor C_b is explained in the text.

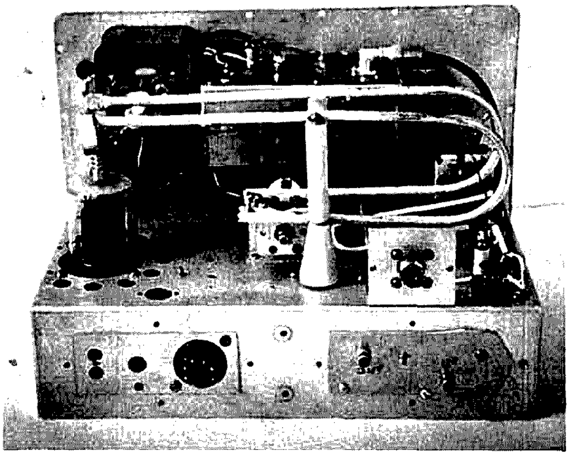
damental. It can be set to frequency with a grid-dipper by temporarily connecting *C1* across *L3*.

Potentiometer R1 can be adjusted to balance *Q2* and *Q3* for minimum third harmonic (174 MHz) output. Resistor *R2* is a parasitic suppressor. The purpose of *C2*, *L6*, and *R3* is to load the output of *Q4* at all frequencies except 116 MHz, and thereby discourage parasitics. The extremely low L:C ratio combination of *C2-L6* is parallel resonant at 116 MHz and thus prevents power loss into *R3* at the desired frequency.

The LO output is loaded by the 12AU7 transmit mixer (**fig. 3**), and *Q4* should be stable with the 12AU7 heater turned either off or on; or for that matter, under any load conditions. The LO is best checked for parasitics with a spectrum analyzer; if one is not available a tunable UHF receiver can be used. Enough 116-MHz drive should be available to produce at least 1 mA of grid current from the 12AU7 mixer, or 22 volts measured at the test point.

transmit mixer

The 12AU7 transmit mixer shown in **fig. 3** is a *doubly* balanced mixer. Most vacuum tube mixers described in Amateur literature to date have been either singly balanced, or simple unbalanced types. What is worse, the singly balanced mixers are usually balanced for the high-frequency signal, not the LO



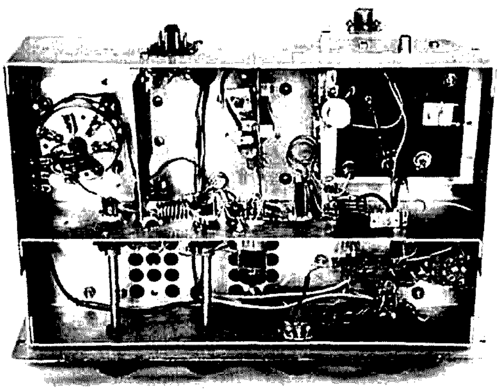
The 5894 plate lines have been bent back upon themselves to save space. Metal box behind plate lines houses the receive converter.

signal. **Fig. 4** shows the difference. No particular advantage results from a mixer that is balanced with respect to the transceiver output since there is little chance that 28-MHz energy will get through the 144 MHz tuned circuits and be radiated by the antenna. But it is important that the mixer be balanced with respect to the LO port to suppress the 116-MHz signal.

The 12AU7 balanced mixer requires about 1/2 watt PEP of 28-MHz drive from the transceiver. The 144-MHz output is linear up to a level of about 1 watt — more than enough power to drive the 5894 class AB_1. Perfect rf balance of the 12AU7 requires equal grid-to-plate capacitances in the two triode sections. The mixer will work well with unequal capacitances but will not completely reject the LO. If desired, the two sections can be equalized by adding a small capacitor to the triode section with the lesser C_{gp}. Two short insulated wires twisted together will provide enough capacitance (C_b in fig. 3).

The trimmer capacitor in series with the primary of *T2* can be adjusted for minimum SWR at 29 MHz as measured with a sensitive (low power) reflectometer or impedance bridge.

Three tuned circuits are used between the mixer and the 5894 grids. It might have been possible to get by with two, but the extra filtering certainly does no harm. One of the three is the grid coil of the 5894, *L14*, which broadly resonates to 145 MHz with the



Underchassis view. Controls at lower left are, from left, the 5894 grid control, C5; 12AU7 plate control, C4; bias-adjust pot, R4; and the grid-meter switch. The 5894 PA tube-base compartment is at upper left. Shielded box at upper right houses the heterodyne oscillator.

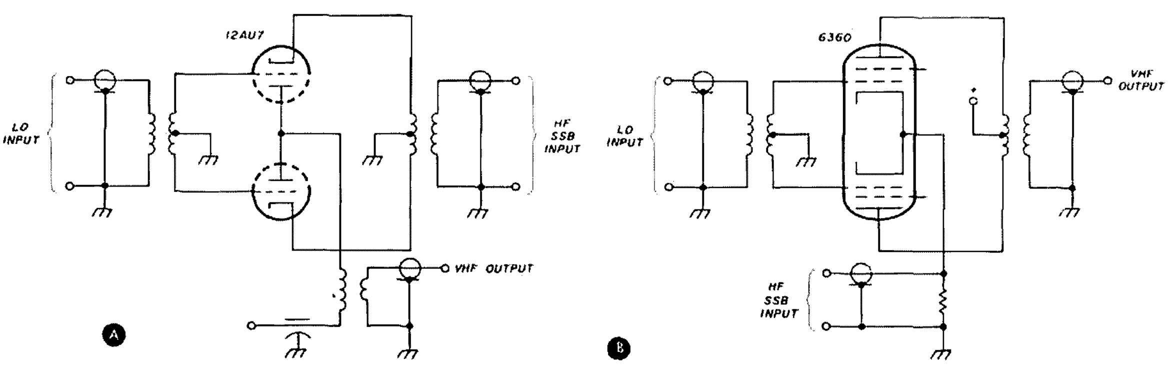


fig. 4. The right and wrong ways to make a balanced mixer. Shown at (A) is a doubly balanced mixer with a push-pull LO input and single-ended output, which isolates the LO from the output port. At (B) is the way it is usually done, push-pull in and push-pull out, which provides no isolation for the LO in the output.

5894 input capacitance. The other two, *C4* and *C5*, are separately tunable by front panel controls. These two capacitors could have been ganged into one control, but I did not bother to do so because large frequency changes are not frequent at my station. The position of the swinging link, *L13*, should be experimentally optimized with respect to *L14* for maximum grid drive to the 5894.

final amplifier

Stability of the 5894 final required that plate current be fed to the half-wave plate line through the two 100-ohm, 1-watt resistors shown in **fig. 3**. These resistors will not absorb any significant amount of 144-MHz power provided they are tapped onto the line at the point of minimum rf voltage. The exact point can be determined by sliding a screwdriver blade along the line and noting the point where detuning is minimum.

The 100-microampere grid meter can be switched to also function as an rf output meter, or line sampler, for tune-up. Rf voltage is rectified by the 1N914 diode, which is very loosely coupled to the coax output connector. The 1N645 diode across the meter terminals prevents meter damage from accidental over-deflection.

Resting plate current of the 5894 is set between 35 and 40 mA by adjusting the dc grid bias to the vicinity of minus 26 volts. The bias adjustment pot, *R4*, is a front-panel control. Ten-meter drive is normally adjusted so that grid current appears on only occasional voice peaks.

The position of the output coupling link is critical, and should be adjusted for maximum output to a 50-ohm matched nonreactive load under full drive conditions; that is, with about 50 microamperes of 5894 grid current.

receive converter

Fig. 5 shows the down converter, consisting of the rf stage, *Q5*, and the mixer, *Q6*. Bipolar transistors have a poor reputation for cross modulation immunity, but no problems with cross modulation have yet been experienced. There are many low-noise transistors that could have been used in the rf stage; the Microwave Associates K6001 was used only because it happened to be on hand. No neutralization was found to be necessary, and the noise figure turned out good without much time spent on adjustments. Collector current of the rf stage is about 1 mA, and the mixer runs at about 0.5 mA. The rf stage collector current can be disconnected by a front-panel switch, S3, to prevent cross modulation from strong signals. This switch is also useful for ascertaining that the received signal is actually a 2-meter station, and not 10-meter leak-through.

The three tuned circuits ahead of the mixer provide about 40 dB of image rejection. The image band is in TV channel 6, and 40 dB will not be enough in strong channel 6 areas. If trouble is experienced with channel 6 interference, an 87-MHz trap can be added to the converter input.

The 116-MHz injection for *Q6* is picked off *L9* by a very loosely coupled tuned circuit (*L7* in **fig. 3**). Less than a milliwatt of injection is needed. Mixer performance can be tested by disconnecting collector voltage from *Q5*. When this is done, receiver noise output should drop by at least 10 dB.

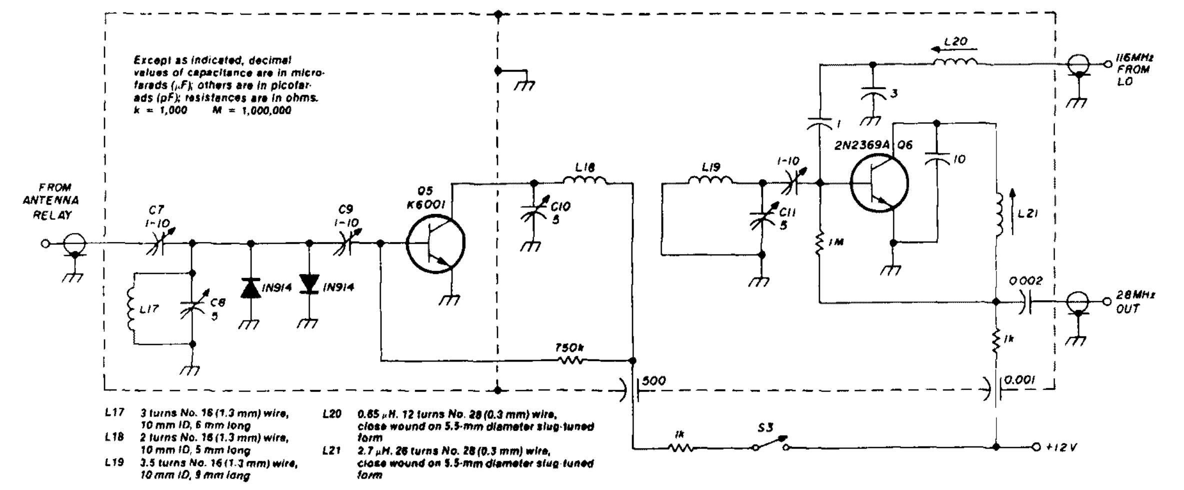


fig. 5. Receive converter. Two-meter signals are amplified by Q5 and converted to 28 MHz by the mixer, Q6. The 1N914 diodes at the input are for overload protection.

The three trimmer capacitors *C8*, *C10*, and *C11* are peaked for maximum gain at 145 MHz. Capacitors *C7* and *C9* are adjusted for minimum noise figure from a 50-ohm source; these adjustments will not coincide with maximum gain.

power supply

The transverter requires 12 Vdc at about 65 mA, 12.6 Vac at 1.2 amps for heaters, 250 Vdc at about 30 mA, minus 50 Vdc at 1 mA for bias, and 800 Vdc at about 150 mA peak. If your transceiver is a tube type, or uses tubes in the final, these voltages can be obtained from the transceiver power supply, since the transceiver final will not be used when transverting. Also needed is a 12-Vdc source controlled by the transceiver push-to-talk switch for the transmit-to-receive change-over relays, RY1 and RY2.

construction

Old timers will recognize the cabinet and chassis as the remains of a Viking 6N2, a 6 and 2 meter a-m/CW rig manufactured by E.F. Johnson in the 1950s. However, any chassis of similar size can be used. The 6N2 was stripped down almost completely; about the only items left intact were the 5894 socket, the plate lines (which were shortened 2 inches, or 5 cm), and the plate-current meter. When rebuilt, the front panel ended up with a couple of empty holes; these were filled in with body putty, sanded smooth, and the panel repainted.

The usual common-sense VHF construction practices should be adhered to. Most of the rf bypass capacitors are 100 pF, as this value, with short leads, is approximately series resonant at 2 meters. The receive converter is built on double copper-clad circuit board and housed in a completely shielded box. The heterodyne oscillator is built on a 3 by 4 inch (7.6 by 10 cm) circuit board and placed in a shielded compartment located on the underside of the chassis to keep it away from final-amplifier rf. This also keeps it away from most of the heat, which would cause frequency drift of the crystal oscillator.

results

A spectrum analyzer was used to search for spurious products in the 0-300 MHz range. All were found to be more than 50 dB below full output. On-the-air reports of audio quality have been unanimously favorable.

The rig has been used on the air for some months now and many enjoyable contacts made. Without qualification it can be said that if you haven't tried VHF SSB, you are missing one of the best operating modes available to the Amateur.

ham radio

operation upgrade: part 3

The third part in a continuing series designed to help you upgrade your ticket

The first two articles in this series provided information that should aid you in understanding electrical and radio theory, and in upgrading your license. They discussed what are known as passive devices. Passive devices do not do much by themselves to change things, but rather react to an application of energy, in a linear manner. The term *linear*, applied to electrical devices, means that if you increase the current through them, or the voltage across them, their fields will increase proportionally. But they do nothing too startling when in use.

Some examples of passive linear devices are resistors, wires, inductors, transformers, choke coils, and capacitors. Take a resistor for example. When current flows through it, it heats up. Of course, it also decreases the current flow in any circuit in which it is placed, and when current flows through it a voltage-drop is developed across it that can be quite useful. A wire develops a magnetic field around it when current flows through it. Such a magnetic field can be increased by coiling the wire. Transformers and choke coils are two applications of coiled wires that make use of the magnetic fields created by current flow. When a capacitor is charged, by applying a voltage across it, an electrostatic field is developed between its plates. The energy that charges the plates and creates the electrostatic field can be stored and used at a later time.

In this article we will discuss some of the active electrical devices and their uses. Active devices alter the voltages or currents applied to them in some way. Usually, the resulting currents and voltages are nonlinear, or distorted in waveshape to a greater or lesser extent. Just for *historical interest* we will discuss the vacuum devices first. Except as final amplifiers and in oscilloscopes, vacuum tubes are playing a smaller role in radio each year.

vacuum diodes

In our first article, it was pointed out that if a metal plate is placed inside a lamp globe that has all of the air pumped out of it, a diode, or two-element vacuum tube, is created. The basic use of such a diode is rectification; that is, changing alternating currents to pulses of one-way or direct current (dc). A diode of this type, as used in a simple *power supply* circuit, is shown in **fig. 1**.

In this power supply the transformer has a 1:2 turns ratio. If 120-volt ac is applied to the primary (which has fewer turns), 240 volts ac will appear across the secondary. Since we normally talk about ac in effective, or RMS, terms, this means that the peak voltage across the secondary will be 240 times 1.414 (factor for converting RMS to peak), or about 340 volts. When the top of the secondary (connected to the plate) is made 340 volts positive with respect to the bottom, electrons being given off by the hot

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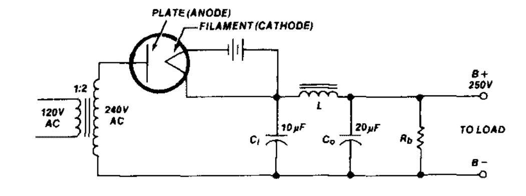


fig. 1. Vacuum diode used as a rectifier in a simple half-wave rectified power supply.

filament (cathode) are attracted to the plate (anode). When the filament loses electrons it pulls others through the iron-core choke coil, through the *bleeder* resistor, R_b, and from the negatively charged (excess electrons) bottom of the transformer. This completes the electric circuit and allows current to flow through it, including the resistor. The voltage-drop developed across the resistor will be the output voltage of this power supply, and may range from nearly 340 volts dc down to perhaps 220 volts dc, depending on how much current is being drawn out of the supply by the load connected across it.

The output from this power supply is affected by several factors. For one thing, the current flowing will be pulsating dc. Only on the ac half cycle of the secondary, when the diode plate is positive, can current flow through the tube. If the plate is negative, no current can flow because the plate is not hot and does not give off electrons the way the filament does. The pulsating dc sees quites a bit of inductive reactance (X_L) in the choke coil in series with the circuit. The opposition effect of X_L to varying or pulsating currents tends to prevent the current pulses from ever achieving their maximum possible value. Also, the capacitors across the circuit charge up to whatever voltage is developed across the circuit at any given time. Both the bleeder resistor and the inductive reactance of the choke prevent the output capacitor, C_o, from charging instantaneously. As a result, a full 340 volts never appears across the circuit output. The more current the load demands (the lower its effective resistance), the less the voltage that can be developed across the capacitors and the less will be the output voltage of the power supply. Within limits, the larger the capacitance values used the closer the output voltage will approach the secondary's peak value.

Although the current in the transformer secondary is pulsating, the effect that the charging and discharging of the capacitors through the inductor and resistor have is to smooth the voltage across R_b to a slightly varying dc, or to a nearly smooth dc if the load demand is light. However, the heavier the load the lower the output voltage and the greater the variation in the output voltage. Can you see that, if the job of a power supply is to supply a smooth dc voltage and current to a load, this one may not do the job under heavy loads?

The circuit shown in **fig. 1** is known as a half-wave rectifier because it uses only half of each ac cycle fed to it. Furthermore, the circuit as shown is not very practical because the filamentary cathode is being heated by a battery. It would be much simpler to add a second low-voltage secondary to the transformer and use this *tertiary* (third) winding to heat the cathode, as shown in **fig. 2**.

A rectifier-filter circuit that you are very likely to find in much older ham equipment is the center-tapped transformer full-wave rectifier power supply shown in **fig. 2**. In this circuit, on one half-cycle of the ac, one diode plate is positive and current flows upward through R_b and the filter capacitors charge. On the other half cycle the other diode plate is made positive and again current flows upward through R_b. Since current flows both to the load and to charge the filter capacitors on both half-cycles of the power line ac, the circuit is known as a full-wave rectifier. Actually, transformer secondary current flows only in pulses. The pulses charge the filter capacitors with energy which is stored until required. This energy can be fed to the load from the capacitors whenever the secondary ac voltage is less than the voltage to which the capacitors are charged, otherwise the transformer is supplying energy to the load.

Fuses may be found at either of the points marked *X*. They will protect against damage caused by short circuits in the load circuit, or if the capacitors short out, or if the tubes or choke short to ground.

vacuum triodes

The development of the three-element, or triode, vacuum tube made possible the great gains achieved

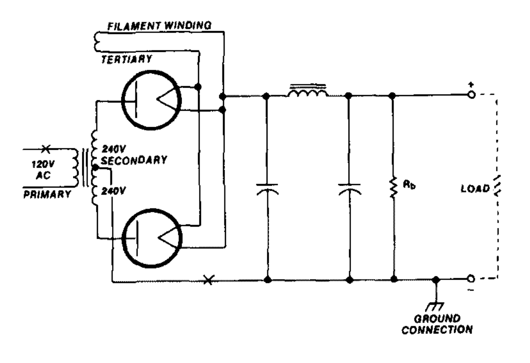


fig. 2. Full-wave center-tapped vacuum diode power supply with a π-type capacitive input filter.

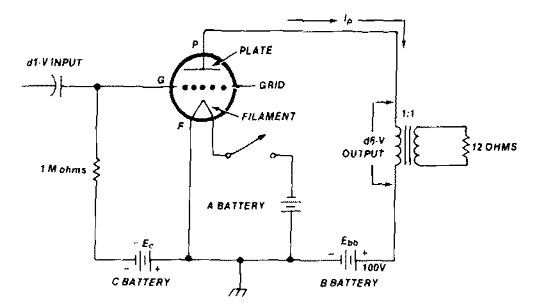


fig. 3. Basic filament-type triode af amplifier stage.

in the early days of radio. Essentially all radio equipment made before about 1955 used vacuum tubes of the triode type or improvements on the triode. Even today, many of the higher power transmitter amplifiers have one or more vacuum tubes as the active devices in them.

When it is desired to produce an ac voltage higher than is available, it's possible to use a transformer with a step-up ratio. But when you want to have a greater ac *power* output than is available from an antenna (or other ac source), it's necessary to use an amplifying device of some kind. This is where the triode idea comes into use, whether it be in the form of a vacuum triode or a semiconductor triode-type device. First, let's see how one of the older types of vacuum triodes worked.

If a vacuum diode has a gridwork of fine wires inserted between the filament and the plate, with a connecting wire brought outside (as indicated in **fig. 3**), the result is a triode tube. You can see that any electrons moving from the hot filament to the plate must pass through the holes between the wires of the grid. If the grid wires have no electrical potential (voltage) applied to them, the electron flow to the plate will not be affected to any great extent. If, however, the grid is given a *slightly negative charge with* respect to the filament by connecting the negative terminal of a "C" battery to the grid, electrostatic lines of force are developed from grid to filament. Since these lines of force are being developed in a direction opposite to the electrostatic lines developed by the "B" battery from filament to plate, they oppose electron flow to the plate and the plate current (I_p) becomes lower. As the C-battery "bias" voltage is made more negative, the plate current decreases further. If the bias is made negative enough, the I_p can be cut off completely.

If the B battery has 100 volts and it takes only -10 volts of C battery bias ($-E_c$) to cut off or reduce the I_p to *zero, then the grid is ten times* more effective in controlling plate current than the plate circuit supply voltage (B+, +B, or E_{bb}) is. It is said that the triode has an amplification factor, or mu (μ), of 10. This implies that 1 volt ac applied between grid and cathode will produce a 10-volt variation in whatever is used as the load in the plate circuit. This could not be attained, however, unless the plate load impedance were infinite ohms, which would mean the circuit would not work. In practicable circuits, the amplification, or *gain*, of such a circuit is usually only a little more than half of the mu value of the tube. You can expect that a 1-volt variation in the input or grid circuit of a 10μ tube will produce approximately 6 volts of varying voltage-drop across the output or plate circuit load. Such a voltage increase could also be accomplished by using a 6:1 ratio step-up transformer of course. But let's see what the *power* advantage of the tube will be over the transformer.

First, the input circuit current of **fig. 3** can be found by Ohm's law to be $I = E/R$, or 1/1,000,000, which is one millionth of an ampere (1 μA). The power input is therefore $P = EI$, or 1(0.000 001), or one millionth of a watt (microwatt, or μW). If the output transformer has a 1:1 ratio, then both the varying dc of the primary and the ac voltage induced into the secondary would be 6 volts. If the load is 12 ohms, the power fed to this output load will be $P = E^2/R$, or $6^2/12$, or 3 watts. This is a power gain of 3,000,000 times by using the triode tube! Such a power gain is possible only because the grid circuit is negatively biased and is collecting no electrons from the cathode. If the grid is allowed to become positive, grid current (I_g) will flow, and power will be lost in the grid circuit. The power gain of the circuit would decrease greatly. Actually, when a triode tube is used as an rf power amplifier in a transmitter, usable power gains of only 10 to 50 are the general result. But that is still 10 to 50 times better than can be provided by any transformer.

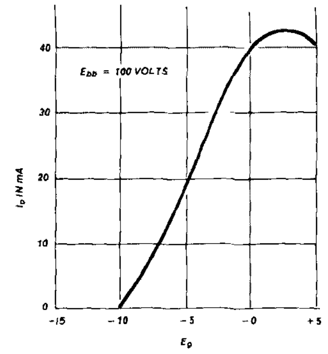


fig. 4. E_gI_p curve of a triode vacuum tube.

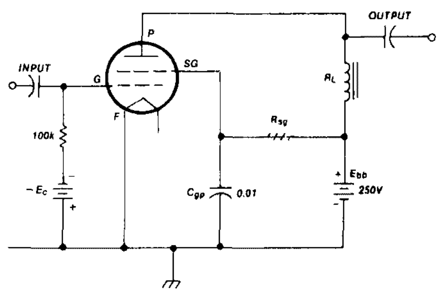


fig. 5. Basic tetrode af amplifier using an af choke as the plate circuit load.

In radio and electronics, circuit operations are often visually explained in terms of curves on graphs. A curve showing how the plate current of a triode will increase as the grid bias voltage is varied is shown in **fig. 4**. We say that the dc plate current is plotted against grid bias (using both negative and positive grid circuit potentials in respect to the cathode in this case). The curve shows that with -10 volts bias the plate current is reduced to zero (cuts off). With -5 volts $-E_g$, the I_p is about 18 milliamperes. At zero bias the I_p is about 40 mA. When the bias becomes positive the I_p increases with an increase in positive bias, but then no longer increases and begins to decrease as the bias increases. At this last point we say that the plate circuit is *saturated.* The triode is passing all the plate current it can with the filament at its present temperature. Higher filament *current* would release more electrons from the cathode and more I_p would result, but this might shorten the filament life, or even burn out the filament wire. Note that the plate supply voltage, E_{bb}, is a constant 100 volts on the graph. Changing E_{bb} would shift the curve to the left or right, but the curve would still have the same general shape.

tetrodes and pentodes

While you will probably not be asked much about vacuum tubes on license tests, it is important that you understand something about the multigrid tubes called tetrodes and pentodes, since they are often used in linear amplifiers for Amateur transmitting systems and are used in most of the older transmitters, receivers, and test equipment you might be using.

One of the difficulties with triode tubes when used in rf ac amplifiers is the capacitance between the grid and plate elements. Both of these elements are metal and they are separated by a vacuum dielectric, thus creating a low-capacitance capacitor. This capacitance can feed amplified high or radio frequency (rf) ac in the plate circuit back into the grid circuit, which is then reamplified to the point that the circuit starts generating ac instead of just amplifying it. This is great if you are building an oscillator (rf generator), but is definitely not desirable when all you want to do is to amplify an ac signal. One method of cutting down on this regenerative, or positive, feedback is to install a second grid between the first *control grid* and the plate, as indicated in the tetrode, or four-element, VT symbol in **fig. 5**. The second grid is known as a *screen grid.* With a screen grid in a tube, any amplified ac is now fed back to the screen grid, and since this element is usually bypassed to cathode (ground) with a relatively large capacitance (0.01 μF), the fed-back ac goes harmlessly to ground and does not get to the grid to produce trouble. Whereas practical voltage gains of perhaps 100 or so are possible with triodes, with tetrodes the gains can be two or three times this value. The screen grid is always connected to a B+ value, either equal to the plate value, or to some lesser voltage value (usually by using a screen grid resistor, R_{sg}). The screen grid also draws current from the "space-charge" electrons around the hot cathode, and represents a power loss to the tube. This is because these electrons do not find their way through the output or plate circuit and the load.

In addition to the power loss when using a screen grid, there is another difficulty. The high positive potential of the screen grid accelerates the electrons on their way to the plate so much that some of them strike the plate hard enough to bounce two or more electrons off the plate surface. These electrons liberated from the plate may move to the screen grid and never flow through the output circuit load. This is also a loss to the output of the tube. Such an undesirable "secondary emission" (the cathode produces the primary emission) can be prevented from moving back toward the screen grid by properly engineering the geometry of the wires of the two grids. If this is done, the primary emission current is formed into intense beams of electrons which sweep any secondary emission electrons back to the plate where they can flow through the load. A tube constructed in this manner is called a *beam power tetrode*, and is the usual multigrid tube used in Amateur linear amplifiers.

Another way of preventing secondary emission electrons from moving to the screen grid is to put a third grid, called a "suppressor grid," in between the screen grid and the plate and applying a zero (cathode) potential to it, as in **fig. 6**. The zero potential area in front of the plate tends to slow the primary emission electrons so that they do not hit the plate with enough velocity to produce secondary emission. If any is produced, the zero potential area will slow them and they will not have enough velocity to

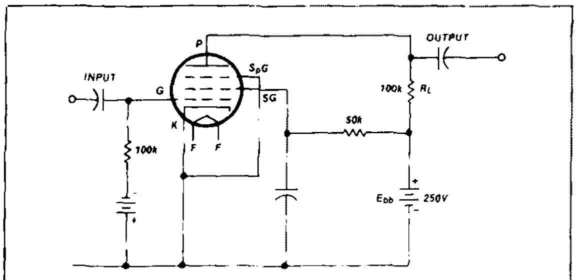


fig. 6. Basic pentode af amplifier using a cathode-type tube.

get to the screen grid. This forms a *pentode* (five-element) tube. Pentodes have even greater gain than tetrodes, and are found in most of the high-frequency amplifier stages of almost all vacuum-tube Amateur equipment in use today.

You will note that **fig. 6** also shows an improvement on the simple filament by the addition of a cathode covering around it. If power line ac is used to heat a filament the alternating current produces a continual heating and cooling of the filament wire, which produces a slight variation of the I_p at a frequency twice that of the filament ac. This produces a nasty hum component in the output current of the stage. *By encasing the filament wire in a metal cathode* sleeve painted with a substance which liberates electrons easily, the variations of filament temperature are not apparent in the slowly heating and cooling cathode sleeve, and the I_p no longer has the undesirable hum component in it. Most VTs use heater-cathodes, very few use simple filaments.

Many of the smaller, modern, low-power or "receiving" vacuum tubes have seven pins protruding from the bottom of a tubular glass envelope which may be about 3/8 × 1-3/4 inches (18 × 45 mm) in size. When VTs are manufactured with two or more devices in one envelope (twin-triodes, diode-pentodes, and so forth), they usually have nine pins at the base of a tubular glass envelope measuring either 7/8 × 1-3/4 inches (21 × 45 mm), or 7/8 × 2-1/2 inches (21 × 62 mm). Transmitting and high-power VTs will be considerably larger, and some may have metal fins attached to their plate, as the external part of the encapsulating shell or envelope. This allows the plates of these tubes to be air cooled by convection or by fans, making possible greater power output from smaller tubes. When the plate is inside a glass envelope, cooling depends on the radiation of heat energy through the glass, which limits the dissipation of heat developed on the plate by plate current (electrons striking the plate). Some tubes are built with metal envelopes to allow their internal elements to be shielded from external fields, but most glass tubes must have metal shields slipped over them to provide shielding. The shields must be grounded to the equipment chassis or the ground connection of the circuit.

solid-state diodes

Today very few if any Amateur Radio power supplies will use vacuum or mercury vapor (gaseous) rectifier diodes. Semiconductor or solid-state diodes are used almost exclusively. Although solid-state diodes may not withstand as much inverse or reverse voltage (negative voltage to the anode) as will high vacuum diodes, several solid-state diodes can be used in series. This does away with the requirement for heating filaments and greatly increases overall efficiency as well as decreasing size and weight of equipment.

There are two semiconductor materials commonly used in the manufacture of solid-state devices. One is silicon, the other germanium. By themselves, in pure crystalline (intrinsic) form, both silicon and germanium are fairly good insulators at room temperatures. However, if an impurity such as arsenic or phosphorus is added to them during the development of the crystals, a semiconductor is formed which has considerably less resistance. In this case, the semiconductor material acts as if it has some free electrons (negative *charge), and is therefore called* N-germanium or N-silicon. If warmed, such semiconductors shake loose their electrons much more easily and have still less resistance. If cooled their resistance increases.

If the dopant, or impurity, is gallium or boron, the semiconductor acts as if it lacks an electron and has a somewhat positive charge, and is called P-germanium or P-silicon. The crystals have a few areas which appear to lack electrons. These areas are considered to be positive holes. While holes do not move, if an electron moves into a hole area the area from which it came is left with a more positive hole. Germanium usually has a lower resistance than sili-

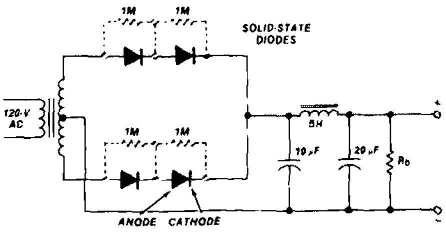


fig. 7. Solid-state diodes used in a center-tapped high voltage power supply. Dashed equalizer resistors would normally be used.

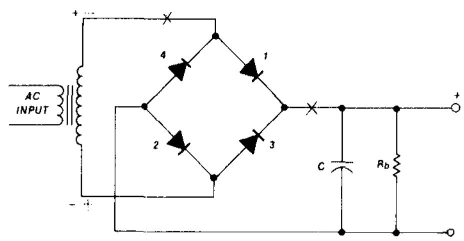


fig. 8. Solid-state bridge rectifier circuit used to provide an unregulated dc output.

con, but silicon is less fragile and is the more generally useful material. Other semiconductor materials are also used.

When an N-silicon and a P-silicon crystal are grown together, the junction between them has some of the N-material electrons moving into the P-material holes. This develops a zero charged barrier area at the junction. Germanium as the semiconductor requires about 0.3 volt to overcome the barrier potential; silicon requires about 0.6 volt. If higher voltages are applied to these diodes, with a negative potential to the N-material and positive to the P-material, current will flow through the device easily. If the applied voltage is reversed, the barrier area is increased in width and no current can flow through the junction and the diode. In this way the PN junction acts as a diode, rectifying ac that is applied across it. PN-junction diodes have peak-inverse-voltage (PIV) ratings of from a few volts up to about 1000 volts. For higher voltage operation several diodes may be connected in series, cathode-to-anode. Often a 1-megohm resistor is connected across each diode to act as a voltage divider to ensure equal voltage-drop across all diodes during inverse peak voltage times. The diagram of **fig. 7** shows solid-state diodes in a center-tapped full-wave rectifier-filter power supply, similar to the VT circuit shown in **fig. 2**. Two series diodes are shown in each leg of the circuit to provide greater PIV protection. (Adding 0.01 μF capacitors across the diodes sometimes reduces buzzing sounds in nearby receivers.) Don't forget, electron current flows in a direction opposite to the arrow of the solid-state rectifier symbol, which means an upward current through R_b.

With solid-state diodes, a full-wave bridge rectifier circuit can be used which does not require a center-tap connection on the transformer secondary, **fig. 8**. With the secondary polarity as shown (+ at the top and − at the bottom), electrons are attracted to the top of the winding through diode 1, through R_b, through diode 2, and from the negative potential at the bottom of the transformer. The voltage-drop across R_b resulting from this current charges capacitor C. On the next half cycle (+ at the bottom and − at the top of the transformer, shown dashed), electrons are drawn up through R_b and through diode 3 to the bottom of the secondary, and out the top and through diode 4 to R_b, again charging C in the same polarity. This results in full-wave pulsating dc flow in the transformer and a reasonably steady or smooth dc voltage across C as the output of the supply.

When used for relatively high voltage and low current circuits, such as vacuum tube equipment, the filter may be a π-type with an input and output C of perhaps 10 to 20 μF, and a choke coil (5 to 10 H) as shown in **figs.** 1, **2**, and **7**. More often, in the low voltage and relatively higher current supplies used with solid-state devices, only a single filter capacitor such as C is used. It may have capacitance values of from 1000 to more than 10,000 μF. Because of the low impedance of such large capacitors to the first ac pulse to be rectified at turn-on, either a small iron core choke or a 1 or 2 ohm current-limiting resistor should be included in the circuit at either of the points marked X. In all of these supplies the output voltage will drop when the load is increased. Power supplies of this type may work well for loads that do not change, but for changing loads (CW, SSB) their voltage regulation may be inadequate. We say that they have too high an impedance.

FCC test topics

The following Novice class FCC test topics are discussed in this article, but should be understood by Technician/General and Advanced class license applicants also:

- vacuum tubes, appearance, applications, symbols.

The following Technician/General FCC test topic is discussed in this article, but should be understood by Advanced class license applicants also:

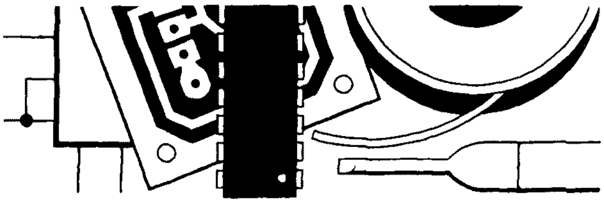
- power supplies using solid-state diode rectifiers.

In the next installment, part 4 of Operation Upgrade, I will be discussing diodes of the following types: zener, tunnel, varactor, hot-carrier, junction, point-contact, PIN, light-emitting, neon, and point-contact. Transistors of the following types will also be discussed: NPN, PNP, junction, unijunction, power, germanium, and silicon.

Part 4 will also include an introduction to the following topics: silicon-controlled rectifiers, triacs, voltage regulator circuits, both discrete and integrated, and voltage regulators with pass transistors and zener diodes to produce a given output voltage.

ham radio

the weekender



wireless 220-MHz to 2-meter converter

Looking for something to do this weekend? Here's an easy, low-cost way to add 220-MHz reception to your programmable scanner or 2-meter handheld — without modification.

The availability of low-cost, multiband programmable scanners has provided an easy way to monitor local multiband repeater activity. Most programmable scanners cover the 440-MHz band and some, if not all, of the 2-meter band. In many areas all channels of a scanner could be easily used to monitor local repeaters. However, the one disadvantage of most programmable scanners is that they don't cover the 220-MHz band.

With 220-MHz activity growing, the capability of adding 220-MHz band coverage to your programmable scanner — with no wired connections or physical mods — would be a big plus! This article shows you how to do this, based on the guidelines listed below. The techniques can also be used to add 220-MHz coverage to a programmable, scanning, 2-meter handheld transceiver; but for the sake of simplicity I use the term *scanner* in this article.

conversion guidelines

To preserve the original desirable features of the scanner, I offer the following guidelines as requirements for making the conversion:

1. Performance of the scanner on the existing band or bands must not be degraded.

2. Ability to use the self-contained antenna or antennas of the scanner must be maintained.

3. No physical modifications shall be made to the scanner. If add-ons are required, no wire connections between the add-on and the scanner shall be made.

4. Any add-ons must be self-powered.

5. 220-MHz band sensitivity must be adequate for reception of local repeaters.

6. It must be possible to "lock out" 220-MHz band reception.

7. Cost must be reasonable.

This list of guidelines may appear tough to meet, but fortunately there's a simple solution.

theory of operation

The solution I came up with meets all requirements *listed except that* two "birdies" occur in the VHF low and high bands — one in each. There's a way to move these around if they fall on channels active in your area — more about this later.

The wireless converter consists of just what the name implies — a receiving converter with no wire connections to the receiver. In other words, antennas are used on both input and output of the converter.

This technique works because the signal-level path loss between two close antennas (receiving converter output and scanner input) is compensated by the conversion gain of the typical receiving converter to produce usable overall sensitivity, although it's not as good as that which would be obtained if a direct rf connection were used.

detailed description

The 220-MHz to 2-meter wireless converter I constructed (**fig. 1**) consists of a receiving-type 220-MHz to 2-meter converter packaged in a metal chassis, an ac-power supply (or battery dc source if portable operation is desired), and input and output antenna jacks. In my converter, a BNC antenna jack is mounted in the center of the top of the chassis for the 220-MHz input, and an SO-239 UHF connector is mounted on the rear panel of the chassis for the 2-meter band output.

receiving converter

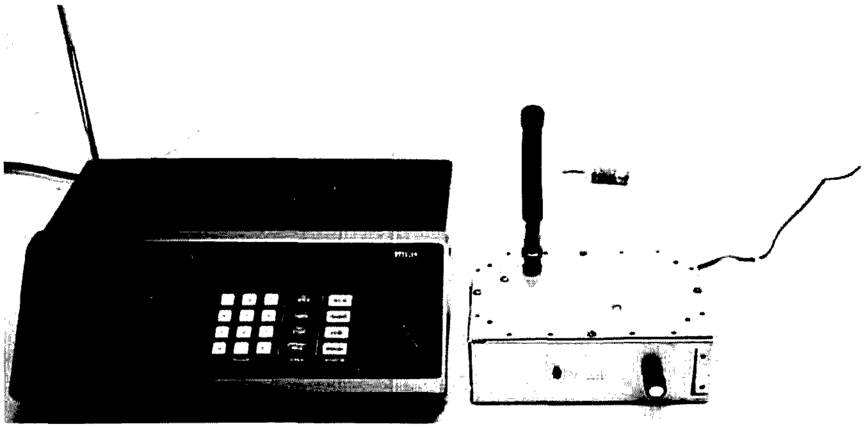
The receiving converter I used in my wireless converter was home built, but any standard receiving converter with the right input and output frequency ranges will work. For example, Hamtronics, Inc. has a 220- to 144-MHz receiving converter, Model CA220-2, which covers the desired frequency bands.

local-oscillator frequency

I chose a 77-MHz LO frequency so that it would be easy to identify received signals between the two bands (a 224.90-MHz input signal would appear as a 147.90-MHZ output signal) and also keep the 220-MHz converted signals within the range of most 2-meter fm receivers.

You may want to select a different LO frequency if the output band of your converter falls in the frequency range of a strong local 2-meter repeater. In my case, a local-coverage 223.94-MHz output repeater is converted to 146.94 MHz. Fortunately, in

By Bob Witmer, W3RW, 79 Blaine Avenue, Leola, Pennsylvania 17540



The wireless 220-MHz converter alongside a programmable scanner. The converter input antenna in this version is a rubber ducky, and the output antenna is a 33-inch (82.5-cm) length of coax with the braid stripped back about 19 inches (47.5 cm).

my area, there are no strong repeater outputs on 146.94 MHz. If this is a problem, and the scanner you are planning to use has the coverage range, you could change the local oscillator frequency up or down, which would shift the corresponding output frequency band by the same amount. For example, if a local-oscillator frequency of 79 MHz were chosen, an input-frequency-band signal of 223.94 MHz would show up in the output band at 144.94 MHz.

birdies

As mentioned previously, the wireless converter may add birdies or spurs to those the scanner already has (depending on the type of receiving converter you use). Most manufacturers list these spurs in their instruction manual. Where these new birdies fall is determined by the local-oscillator frequency that is selected. For example, in my converter, with a LO frequency of 77 MHz, I have birdies at 38.5 MHz *(actual crystal frequency = 77 MHz ÷ 2)* and at 154 MHz *(2 × 77 MHz)*. Where I live these birdies don't interfere with active channels I wish to monitor; if they did, a slight change in the converter's local-oscillator (crystal) frequency would change the frequency where the birdies appear.

Finally, LO frequencies in the 73- to 75-MHz range probably should be avoided because their third harmonics fall in the 220-MHz band.

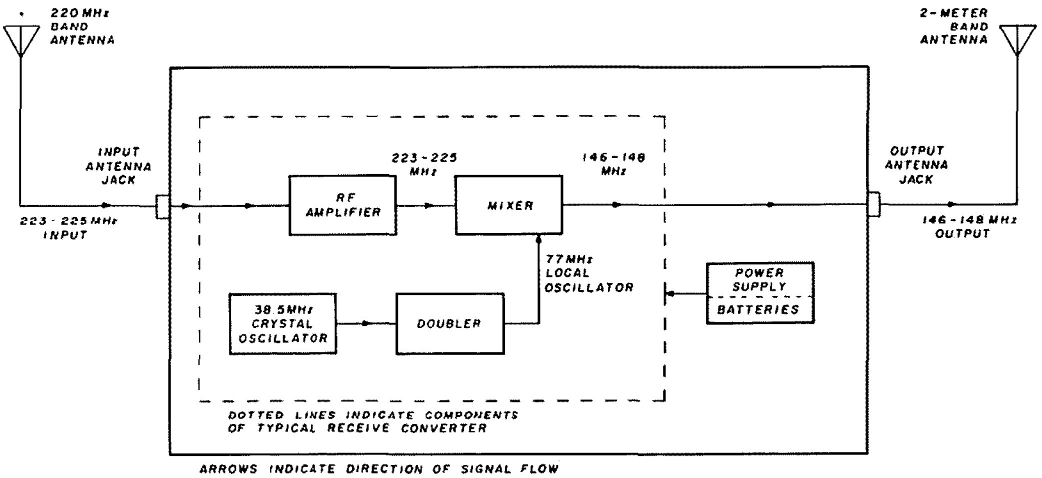
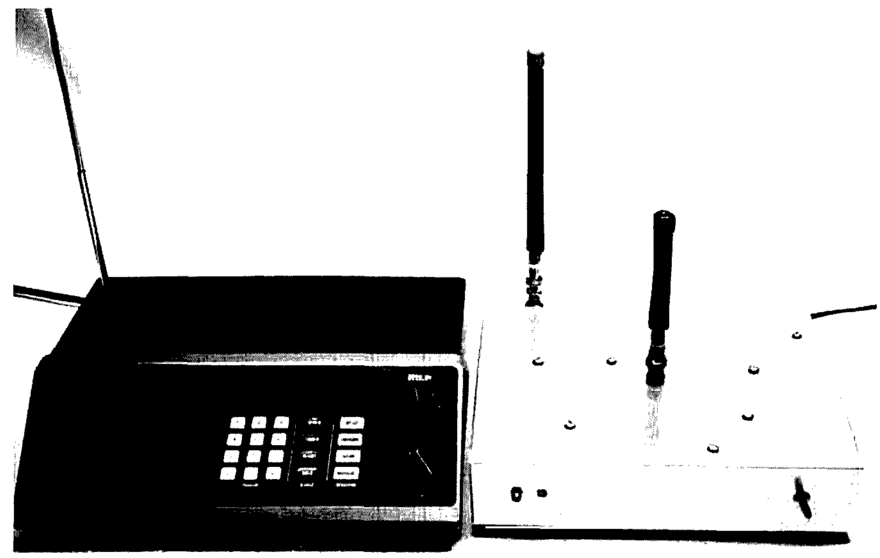


fig. 1. 220-MHz to 2-meter wireless converter block diagram.



A "de-luxe" version of the converter using rubber ducky antennas for input and output.

antennas

I chose a self-contained, 220-MHz antenna (rubber duck) on the input to preserve the portability of the converter, since this makes mobile operation with a 2-meter handheld possible. Reception will be improved greatly if an external 220-MHz antenna is used for the input. A full-length quarter-wavelength whip could also be used. A 2-meter rubber-duck antenna could be used on the output of the converter, although I used a 33-inch (82.5-cm) piece of coax with the braid stripped back approximately 19 inches (47.5 cm).

installation and operation

For best performance, the scanner should be located close to the wireless converter's output antenna. (Place the scanner on top of the antenna if a coax-wire type of antenna is used.) After the antennas are connected and the scanner and converter are placed close together, the scanner and wireless converter can be powered up and the scanner programmed for the 220-MHz repeater frequencies you wish to monitor. To determine these frequencies, subtract the converter local-oscillator frequency from the desired 220-MHz frequency. For example, if the 220-MHz repeater frequency is 223.94 MHz (as in my case), subtracting the LO frequency of 77 MHz puts the scanner receive frequency at 146.94 MHz. If you don't know the local-oscillator frequency of your converter, it can be determined by subtracting the low (or high) end of the output frequency band from the corresponding input-band frequency. For example, if the input upper frequency is 225 MHz and the output upper frequency is 148 MHz, the LO frequency would be 77 MHz.

If you tire of listening to 220 MHz activity, all you need do is turn off the power to the wireless converter to lock out 220-MHz-band reception.

other applications

If the 220-MHz signals you're monitoring are strong, and you position the converter's output antenna somewhat vertically, you can walk away from the wireless converter — in my case one or two rooms away in the house — with a 2-meter handheld receiving on the converter's output frequency and still be able to copy the signal.* This can be useful for monitoring, since chatter from a programmable scanner is often objectionable to others; and with a handheld, you can monitor the converter's output using an earphone with the scanner off.

As mentioned previously, most of this article addresses programmable scanners; but a programmable scanning-type 2-meter handheld could also be used with the converter in a similar way to add 220-MHz receive coverage to existing 2-meter coverage.

10- or 6-meter fm

This technique can be used to add 10- or 6-meter fm-band coverage — the other Amateur bands that most programmable scanners don't cover. Just select a receive-type converter with the desired input and output frequencies, add antennas and a power source, follow the guidelines in the article, and you're ready to go.

ham radio

*It is important that the converter's output is not strong enough to interfere with other equipment. Editor.

Questions and Answers

Entries must be by letter or postcard only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio.

Readers are invited to send a card with the question they feel is most useful that appears in each issue. Each month's winner will receive a prize. We will give a prize for the most popular question of the year. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

Why is 60 Hz the standard power-line frequency in this country? — Fred Hegstrom, WA4IEG.

Well, simple questions can turn out to be tough to find the answer to.

Thomas A. Edison used dc to generate power for his illuminating business. The long distance-transmission of dc is inefficient, and Edison soon found that his 110-volt lamps didn't give much light when operating at 85 volts, the result of voltage drops along the line, differences in loads and so forth. So he hired a young engineer by the name of Nikola Tesla, who had plans for an alternating current dynamo that would eliminate the commutator and brushes needed for dc dynamos.

Tesla felt that ac could be transmitted more efficiently by stepping up the voltage through a transformer, having less ohmic losses in the transmission line, and stepping down the voltage again at the user's end.

Tesla told Edison that he could vastly improve existing dc dynamos and Edison said, "There is $50,000 in it if you can." Tesla worked long hours, developed twenty-four different types of dynamos, then asked Edison for his money. Edison replied, "You don't understand our American humor," and reneged on the offer. Tesla quit.

He couldn't get work in the electrical industry at this time and had to go to work digging ditches to keep alive. But his foreman recognized that Tesla was an educated and talented man, so he helped him get financing so that Tesla could form his own company, the Tesla Electric Company. Once in business for himself, Tesla produced three complete ac systems, for single, two, and three phase generation, and the transformers for voltage conversion and also the motors to drive the machines.

Different from Edison, who was an "intuitive" inventor, Tesla was a theoretician who worked out the basic mathematical theory underlying his inventions; and he had already come to the conclusion that the optimum frequency to use was 60 cycles/second. He filed for and was granted seven basic U.S. Letters Patents on his inventions, and was asked to lecture before a meeting of the American Institute of Electrical Engineers in May, 1888. This lecture became a classic in the electrical engineering field.

Meanwhile, George Westinghouse, who had invented the airbrake for railroad cars, was also in the business of making lighting equipment, in competition with The Edison Electric Co. The Westinghouse Electric Co. used a frequency of 133-1/3 cycles per second. This was a result of using an eight pole generator and running it at a shaft speed of 2000 RPM ($f = RPM/60 \times pole\text{-}pairs$) or $f = 2000/60 \times 8/2 = 133\text{-}1/3$ CPS. This system used crude transformers of limited capacity, and required a transformer in each house-to-house connection! George Westinghouse recognized the value of Tesla's work and offered him $1,000,000 for his patents, a royalty of $1/horsepower for each generator and motor he built, plus a generous salary to work for him in Pittsburgh, Pennsylvania. Testla accepted.

At one time in this country we had 133-1/3, 125, 83-1/3, 66-2/3, 60, 50, 40, 30, and 25 cycle power — not to mention a few "odd-ball" frequencies! Remember that the first generators were belt driven from steam engines, making it possible to run the generators at a fairly high speed. With the advent of direct drive-engines (and later, turbines) and also the use of hydro-generators directly connected to low-speed shafts, it became apparent that many pole-pairs would be needed to generate higher frequencies. We still use some 25 cycle power, generated primarily at steel mills to drive very large slow-speed motors for rolling mills. And the first hydro plants were 25 cycles. But the flicker of an incandescent lamp (and today, a fluorescent lamp) at the rate of 50 times/sec (2f) is below the rate at which persistence of vision in the human eye can make the light seem steady.

Edison battled the use of high-voltage ac to the end. He conducted experiments by electrocuting dogs and horses to show that ac was more lethal than dc, and when the state of New York had their first legal electrocution using ac on the electric chair, the "dc lobby" considered this a victory.

But when Westinghouse supplied the power, using ac, for the Chicago World's Fair of 1893, and then got the contract for the Niagara Falls hydroelectric plant, which transmitted power to Buffalo, New York, twenty miles away, the ac vs dc battle was over.

In short then, we have 60 Hz as the standard frequency in this country because of a Serbian immigrant named Nikola Tesla — the father of the induction motor and polyphase transmission. He also did some work in the wireless transmission of power, but that's another tale.

When using a short antenna, why is it after tuning the rig and using an antenna tuner to reduce the SWR I can't get full power forward? — Christopher B. Hays, WB0LPV.

The key word here is *reduce* the VSWR. If the antenna tuner is capable of handling a wide range of complex loads, it should be able to present 50 or 75 ohm *resistive* load to the transmitter pi-network output circuit, even if you use the proverbial "wet-noodle" for an antenna. My computer said "Insufficient Data" — you didn't say whether you are using a true rf watt meter or a "reflecto-scope" (Monimatch, etc.) calibrated in watts.

The antenna "tuner" is just another impedance matching device, as the pi-network in your transmitter is also an impedance matching device, for transforming the load (antenna terminal) impedance to the proper load for tubes or transistors in the final.

Incidentally, I'll wager your "tuner" is a form of transmatch; it doesn't tune the antenna at all, unless it's mounted at the feed point. Don't worry about VSWR or forward power — just tune up for minimum reverse, keep your plate current within limits, and away you go!

P.S. Since you are using six Slinkys indoors, what do you tell the guy you're working that your antenna is? I used the screens on a porch in a condo for nine months and got tired of trying to explain what I was using.

When a ham gives you a report and says his S-meter reads 5 dB over S-9, what is he saying? I am familiar with the decibel and the math needed to calculate it, but I don't understand S-units — Lloyd A. Mullens, KA4LTK.

Forget about trying to use your knowledge of decibels when dealing with receiver S-meters! At one time, it was hoped that 50 microvolts from a signal generator applied to a receiver would make its S-meter read S-9. Each S-unit was 6 dB in voltage, that is, a 25-μV signal would be S-8, doubling it (6 dB) would be S-9. Above S-9, the meters are usually calibrated in 10-dB increments.

There are many factors that influence these meter readings. First, the receiver input impedance can vary from band to band, and even within a band. So a generator that gives us a voltage into 50 ohms may in fact be looking into a very different impedance. (Remember the dB correction for different impedances?) Next, we have dynamic problems resulting from the fact that the meter gets its voltage from the AGC system, which may be audio or rf derived — this, coupled with the fact that the meter's mechanical ballistics will give vastly different readings between receivers tuned to the same signal.

Since there are no standards for the S-unit, the subject of "specmanship" by the manufacturer enters the picture: how were the receiver's sensitivity and bandwidth determined? If you want to use a device to collect meaningful readings (say for antenna work), use a good field-strength meter, not a receiver.

In your own mind, you'll know that a report of less than S-9 means, "I can hear you"; over S-9 means, "My gosh, but you're strong"; and, of course, a rare DX station is always 5 × 9, even though you're not sure of his call.

In building my 80-meter inverted vee, I am limited to a small space, and I would like to know if I can wrap part of each leg around a circular form? — Johnny R. Carter.

Yes, the part of the antenna that's wound into a coil acts as an extension of the antenna. In the typical 40/80 meter trap antenna, the trap consists of a coil (usually 2-3 inches in diameter) shunted by a capacitor; this forms a parallel resonant circuit at 40-meters, making the antenna look as though it's only as long as the distance between traps. But when the antenna is operated a 80-meters, these coils make the antenna look longer than it actually is, hence the term *loading coils*.

Wind the coils, locating them a few feet from the end insulators. Of course make the total length of the antenna longer than formula, and prune it to length for a specific frequency by using an antenna noise bridge, "antenna-scope," or other device to determine resonance. Remember, antennas at this frequency have a high *Q* and the bandwidth for SWR limits of 2:1 are quite small. Pick an operating frequency, and prune the antenna for it.

The highest voltages on this antenna will appear at its ends, so don't put the coil right at the end where it could arc over between turns. Cut-and-try is the best bet here — an inverted vee is merely a dipole (72 ohms) whose feed point impedance is lowered by angling it from the vertical and horizontal.

Since you are going to the trouble of making up the coils, why don't you make them into traps so you get a 40/80 inverted vee? You can take the ends and make them vertical or bend them out at some other angle to get the required length in your *available* space.

Why do manufacturers and others use 2125 Hz and 2295 Hz for RTTY when lower frequencies, such as 800 to 1100 Hz, are better? — Arthur I. Kelley.

Are these lower frequencies really better? Let's see.

In 1955 the FCC permitted Amateurs to use FSK on the high-frequency bands, with a frequency shift of 850 Hz ± 50 Hz. In terms of AFSK, let's take this 850-Hz shift and divide by two; that's 425 Hz. This is the center of the mark-space shift. Now, the fifth harmonic of 425 is 2125 Hz and the seventh harmonic is 2975 Hz. The original requirements were tough, but using Lissajou figures on a scope you could get fairly accurate calibration, at least for the 850 spread between mark and space.

It was found that narrow shifts had advantages, so the FCC amended the R&R's to say "a shift up to 900 Hz." So, leaving the mark tone at 2125 Hz, for a 170-Hz shift we get 2195 Hz for space.

Now, when using AFSK with a good SSB transmitter (using a mechanical filter or high-quality multipole crystal filter), the sideband suppression is good using the 2125-2975 or the narrow 2125-2195 split; the harmonics of these frequencies fall outside the passband of the transmitter. If we used your suggestion of, say, 800 Hz for mark, its second harmonic of 1600, its third harmonic of 2400, and probably to some degree its fourth harmonic of 3200 Hz would be transmitted simultaneously. Now, aside from the unnecessary intelligence (and power) transmitted, unless you can impose very stringent harmonic requirements on your mark/space oscillator, it is wiser to raise the frequency so these harmonics fall outside the transmitter's passband. The advantage of using the same frequency for the various shifts is obvious.

ham radio

a neglected antenna
for 40 and 80 meters
Remember the open-wire, center-fed Zepp?

A superior antenna has been overlooked in this age of drooping doublets and other wire antennas. The antenna system described here is the open-wire, tuned-feeder, center-fed dipole, otherwise known as the center-fed Zepp.

qualifications and assumptions

In the description that follows, I assume that an antenna for 40 and 80 meters should be designed to be compatible with the classic sky-wave (vertical) radiation angles for these frequencies, and that omnidirectional coverage is desired. Also assumed is that an impedance match close to 1.0 is desired between 3.5 and 4.0 MHz and between 7.0 and 7.3 MHz.

The tuned-feeder, center-fed dipole antenna is not for routine contacts into ZL-land, but neither are the 40- and 80-meter bands. The tuned-feeder, center-fed dipole will not replace a rotary beam for point-to-point communications. However, the rotary beam will not replace an omnidirectional antenna for multistation, close-in contacts. Thus, the neglected design described here is best suited for short-haul distances that can be covered on the 40- and 80-meter Amateur bands.

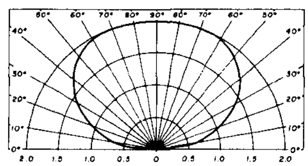
A properly designed tuned-feeder, center-fed dipole antenna, elevated one-quarter wavelength above ground, is unsurpassed for short-haul 80-meter operation. Such an antenna can be matched between 3.5 and 4.0 MHz and provides a high angle of radiation, which is desirable for low-frequency, omnidirectional communications.

This same 80-meter antenna provides a 30-degree vertical radiation angle when tuned to 40 meters. The 40-meter mode does, however, exhibit deep broadside nulls. The purpose of this discussion is to show how the perpendicular, or broadside, nulls can be switched from the sides of the antenna, leaving the antenna with a near-omnidirectional pattern.

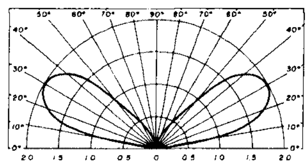
radiation patterns

A review of the *ARRL Antenna Book* shows that:

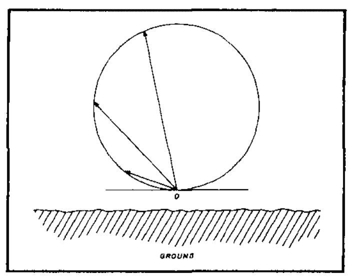
Horizontal antennas one-quarter wavelength high exhibit a vertical radiation pattern at an extremely high angle:*



Horizontal antennas one-half wavelength high exhibit a vertical radiation pattern of 30 degrees:



The radiation pattern of an antenna depends upon the angle of radiation considered:

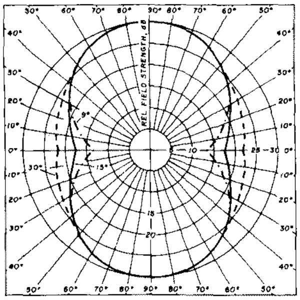


*Drawings reproduced by permission, American Radio Relay League, Inc.

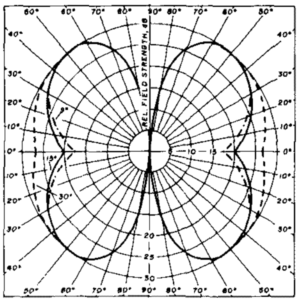
By Warren Amfahr, WØWL, 4309 70th Street, Des Moines, Iowa 50322

As shown by the arrows, the field strength *off the end of a dipole* will be quite different at different vertical radiation angles. (This fact is seldom remembered when discussing high-radiation-angle antennas.)

The radiation pattern of a horizontal half-wavelength antenna for a 30-degree vertical angle is:



The radiation pattern of a horizontal one-wavelength antenna for a 30-degree vertical angle is:



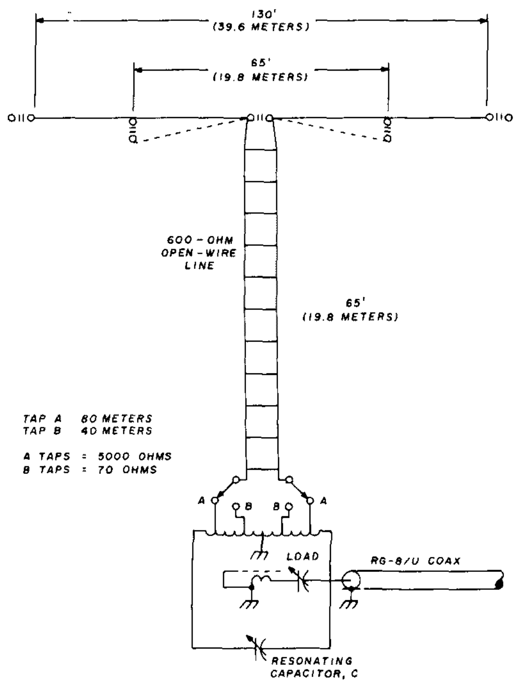


fig. 1. This center-fed dipole has an omnidirectional pattern with a 70-80 degree vertical radiation angle on the 80-meter band. On the 40-meter band, the antenna becomes a full wavelength long, with a vertical radiation angle of 30 degrees, but with a deep null normal to the plane of the wire. The omnidirectional pattern can be restored on 40 meters by adding a 40-meter dipole in parallel with the 80-meter dipole. See text for tuning instructions.

From these graphical representations of antenna radiation characteristics, it can be seen that:

a. The 80-meter halfwave dipole, one-quarter wavelength above ground has *maximum radiation* at an *extremely high* angle.

b. When the same antenna is tuned to 40 meters (one wavelength long at one-half wavelength above ground) the radiation angle is close to *30 degrees.*

c. The horizontal radiation pattern for this 40-meter configuration has *side nulls*.

antenna configuration and impedance matching

The diagram of an open-wire, tuned-feeder, center-fed dipole for 80 meters is shown in **fig. 1**. The typical matching impedance is approximately 70 ohms. With an ideal 65-foot (20-meter) antenna height, a 600-ohm open-wire feeder of this length works as a quarter-wave transformer and transforms the 70-ohm center impedance to an impedance of approximately 5000 ohms. The antenna tuner is tapped to a *5000-ohm impedance on the tuner* coil. (Other variations of tuner impedance matching are possible and are thoroughly covered in the *ARRL Antenna Book*.)

The 80-meter, tuned-feeder, center-fed dipole antenna becomes a full wavelength on 40 meters, with its center at a high-impedance point. At the same time, the feeder length at 40 meters becomes a half wavelength long, and the antenna-tuner impedance taps are essentially equal to those for 80 meters. The only change required in the antenna tuner, from 80 to 40 meters, is its resonant frequency. In practical applications, this is accomplished by a reduction in the capacitance value.*

The initial 80-meter LC is usually *resonated* with large C and small L; then 40 meters can be resonated with low C and high L. In other words, the ideal LC ratio would be chosen at a frequency midway between 80 and 40 meters** ***and then only C (fig. 1) would be varied to cover the two bands.

The antenna described here can, with changes in tuner L and C, become an efficient radiator for other harmonically related bands; however, any serious long-distance communications on the higher bands should be made with directional beams.

Two changes are required to eliminate the side nulls when the antenna is used on 40 meters:

1. The dipole must have a 40-meter halfwave resonant frequency, and

2. The antenna tuner must have a 70-ohm impedance tap.

With this optional configuration, the impedance taps will determine which antenna the halfwave open-wire transmission wire will properly match. The 70-ohm tuner impedance will transfer directly to the 70-ohm center impedance of the 40-meter halfwave dipole. The longer antenna, having a high impedance at the center, does not provide a match to the line and does not accept power. The 40-meter halfwave dipole section of the antenna will exhibit a 30-degree vertical angle of radiation, and the side nulls will disappear. A 600-ohm transmission line can be constructed of 14 gauge wire spaced by 5-inch-long wooden dowels boiled in paraffin. Also, small-diameter acetal rod makes excellent lightweight spacers.

concluding remarks

It's desirable to locate the tuner directly below the antenna center, then remotely tune the device through buried coax and control lines. An additional refinement might be a counterpoise a few inches over the soil. Since 600-ohm open-wire transmission line exhibits only 0.05 dB attenuation per 100 feet at 7 MHz when matched, a long line could be used between tuner and antenna. The line would, of course, require an odd quarter wavelength at 80 meters to match impedances.

The antenna tuner impedance taps can be easily switched by an antenna relay, and a tuning capacitor can be tuned with a gear reduction reversible dc motor. A coax center-lead series capacitor for loading adjustment could also be motor driven. Forward and reverse dc polarized lever switches at the operating position, used in conjunction with an SWR meter, can remotely tune the system to near perfection.

The tuned-feeder, center-fed dipole described here is not a compromise antenna. It requires space, height, and an antenna tuner. The *rewarding return* to the user of such a properly designed antenna is the knowledge that his antenna approaches perfection.

The most significant factor contributing to the superior performance of this antenna is that the antenna's vertical radiation angles closely match the ideal for the 80- and 40-meter bands.

ham radio

HAM CALENDAR January

W1AW Schedule

October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule:

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M., TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M., MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M., TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M., TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M., TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
					BIG ISLAND ARC — Worked All Hawaii Awards available to all licensed Amateurs. Contacts after 0000Z, any mode, any band. Three classes; class A — worked 100 HI stations; Class B — worked 50 HI stations; Class C — worked 25 HI stations. Address award applications to: Big Island ARC, P.O. Box 1688, Kamuela, HI 96743 — 1 **1**	**2**
HAMFEST SWAP & SHOP — First Sunday after New Year's Day at Century Center downtown on U.S. 33 North, South Bend, IN — 3 **3**	**WEST COAST BULLETIN** — 9PM PDT (8PM PST) 0400 UTC, 3540 UTC, A-1 22 WPM — 4 **4**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **5**	**6**	**GIRL GUIDE ASSOCIATION'S JAMBOREE** — in Rotorua, New Zealand, from December 29th to January 7th. The call sign will be ZL1 G.G.A. and will operate on 80 meters (3.690 MHz), 40 meters (7.08 MHz), 20 meters (14.200 MHz), 15 meters (21.350 MHz), 10 meters (28.550 MHz). A QSL card will be sent to all contacts — 1-7 **7**	**8**	**73'S 40-METER PHONE CONTEST** — 9 **9**
OAK PARK ARC — Oak Park, MI, Swap & Shop at Oak Park High School. For more information, send SASE to Rob Numberick, WB8ZPN, 23737 Couzens, Hazel Park, MI 48030 — 10 **73'S 80-METER PHONE CONTEST** — 10 **10**	**11**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **12**	**13**	**14**	**15**	**SARASOTA ARA INC** — Sarasota, FL. For more information contact J.S. Cook, WB4BZL, 2286 Hyde Park St., Sarasota, FL 33579 — 16-17 **SOUTHEASTERN LA UNIVERSITY ARC** — at Hammond, LA. For more information contact Ralph Shaw, K5CAV, Box 402, SLU, Hammond, LA 70402 — 16 **INTERNATIONAL SSTV CONTEST** — 16-17 **16**
SOUTHFIELD HIGH SCHOOL ARC ANNUAL SWAP & SHOP — At Southfield High School, 24675 Lahser, Southfield, MI. For more information contact Robert Younker, Southfield HS, 24675 Lahser, Southfield, MI 48034 — 17 **17**	**WEST COAST BULLETIN** — 9PM PDT (8PM PST) 0400 UTC, 3540 UTC, A-1 22 WPM — 18 **18**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **19**	**20**	**21**	**W1AW QUALIFYING RUN** — 22 **22**	**TEXAS QSO PARTY** — 23-24 **NORTH DAKOTA QSO PARTY** — 23-24 **23**
24 **31**	**25**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **W1AW QUALIFYING RUN** — 26 **26**	**27**	**28**	**29**	**REF CONTEST (FRANCE, CW)** — 30-31 **CLASSIC RADIO EXCHANGE** — 30-31 **CQ 160-METER CONTEST (CW)** — 30-31 **30**

ham radio TECHNIQUES

Bill Orr W6SAI

Winter is here. The static level has dropped and the low frequency bands are alive with DX. In particular, the revivified 160-meter band is hopping. The recent FCC expansion of that band, in addition to all of the transceivers that cover 160, have brought about a high level of activity in a band previously dormant for most of the year.

One-sixty, of course, is where Amateur Radio got its start. The earliest DX was worked on that band. It was the dream of Amateurs in 1921 to make two-way contact across the Atlantic Ocean.

The first listening tests between British and American hams proved to be a failure because of both natural and manmade interference. It was not until December, 1922, that American signals were logged in Europe (Scotland). And quickly thereafter, more than thirty lucky Yankee hams were heard in England, Holland, and France.

But could European Amateurs be heard in America on the "short waves" of 200 to 300 meters? Yes, eventually they would. And finally, as history tells us, on the night of November 27, 1923, signals were exchanged between 1MO and 1XAM in the United States (Schnell and Reinartz) and 8AB (Deloy) in France.

And well might the participants in this historic contact have been proud! I heard the story direct from Reinartz and Deloy some years ago; it was a thrilling account of an exciting adventure in communications,

But was it really the first two-way Amateur QSO across the Atlantic?

I thought it was, and so it is written in Amateur history. But I came across an obscure letter to the editor of *QST* in the August, 1931, issue of that magazine that claimed otherwise. The letter was written to congratulate *QST* for having revived interest in what was at that time a sparsely populated 160-meter band. The story is an interesting one and — well, read it for yourself:

14. N. Michigan Ave.
Chicago, Illinois

Editor, QST*:*

I note the recent stir in QST *regarding the use of the 1715-kc. band and feel that you are greatly to be commended for trying to raise a little interest in this Amateur band. I would like to call to your attention the fact that successful communication has been carried over considerable distance in the past. D.A. Griffin, J.M. Tiffany and myself used to operate old NU2AGB in 1922 and '23 and used to work the Pacific Coast with ease. Our signals were consistently heard in Europe, too.*

Those efforts were crowned with success when we carried a two-way communication with British 2JL at Liverpool in October of '23. This, mind you, on a frequency of 1500 kc. with about 750 watts input to a Hartley oscillator. A Western Electric super was used as the receiver. J.M. Tiffany, at present operating 2CGK, was the operator on watch at this

particular time and the work was corroborated by a ship's operator in mid-Atlantic. We are under the impression that this was the first amateur two-way work with Europe....

John H. Dodman, W9GA, ex-2AGB

Well, there it is. If this report is true, a lot of hallowed Radio Amateur history will have to be rewritten. Did 2AGB actually establish contact with British 2JL a month before the famous 1MO to f8AB contact? If so, why was the information buried until 1931?

Information traveled more slowly in those times, and unless a transatlantic cable of confirmation were sent it

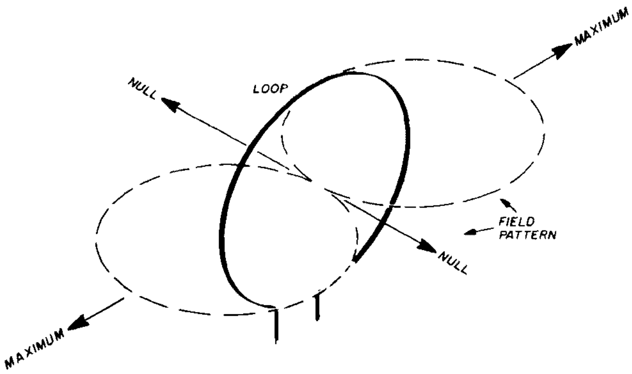


fig. 1. Field pattern of small loop as viewed from above. Maximum response is in the plane of the loop and nulls are at right angle to the loop. This is the reverse of the pattern of the larger "quad" loop whose maximum response is at a right angle to loop plane.

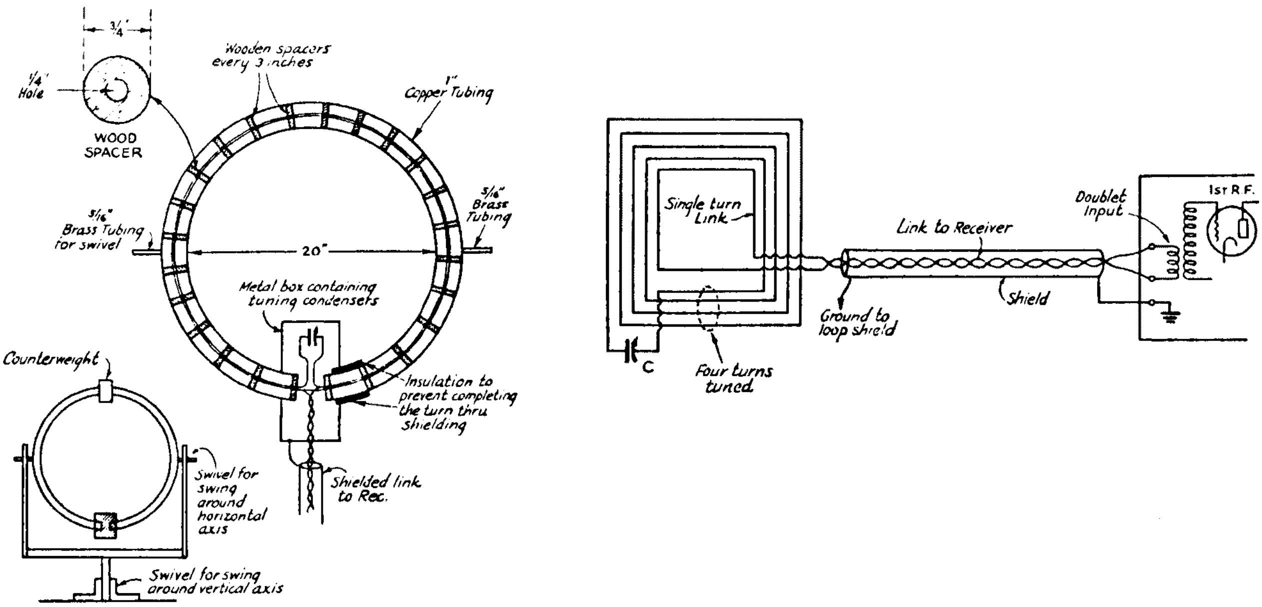


fig. 2. A reproduction of the 1938 *QST* drawings of the W6GPY receiving loop antenna for 160 meters. An electrostatic shield made of copper water pipe surrounds the four-turn loop. One end of the pipe is insulated from ground so as not to include a shorted turn adjacent to the loop. This deluxe design was movable in both azimuth and elevation and, by removing one turn from the loop, was capable of operation on 80 meters.

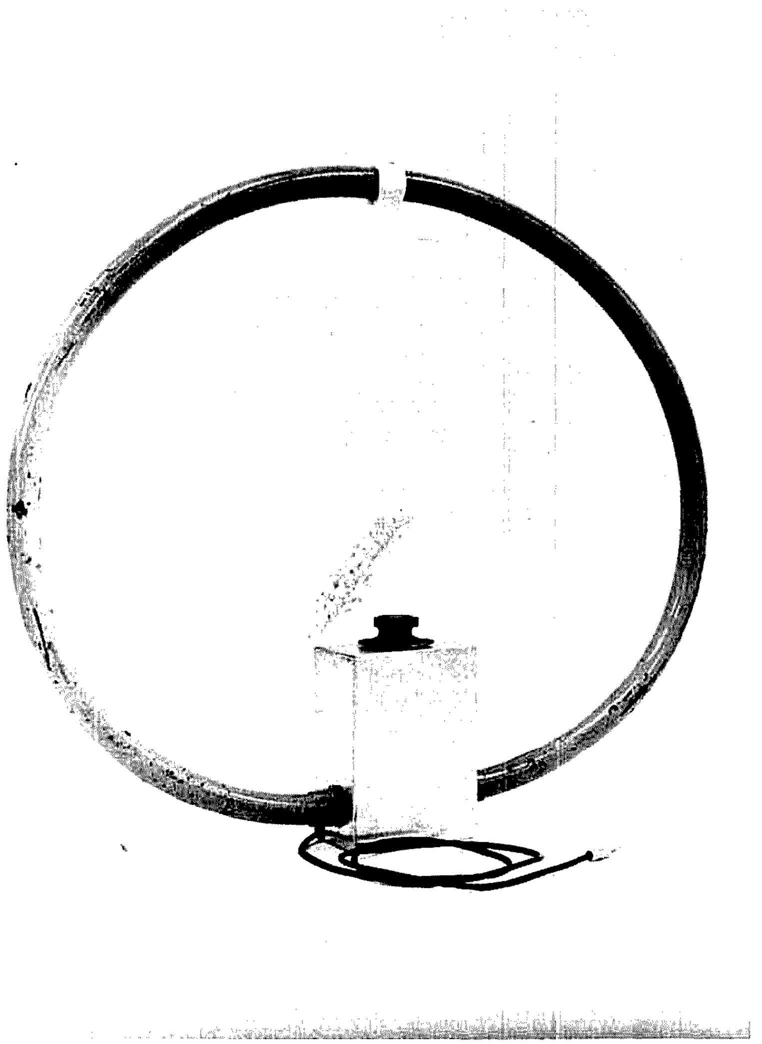


fig. 3. The W6PO version of the W6GPY receiving loop. Bob broke the electrostatic shield at the top with a section of phenolic material for ease of construction. The loop itself is made up of five turns of colored hookup wire, each wire having insulation of a different color. A sixth turn provides the coupling loop for the preselector. The wires are spaced within the 20-inch diameter assembly by phenolic washers. The loop wires are laid out and the washers slipped over them and tied in place. The wires are passed through the loop halves before assembly. Plumbing fittings are soldered to the copper tubing at the bottom to affix the loop to the 3 × 4 × 5 inch aluminum box. The tuning capacitor is atop the box and the coaxial cable to the receiver comes out the side of the box.

Connecting the individual loop wires in series is easy, as they are color coded. Depending upon the number of active turns, the loop can tune from 4 MHz down to about 1300 kHz. Three-quarter-inch-diameter copper water pipe is used for construction.

might have taken months to receive a confirming QSL card (just like today!).

In any event, there the matter rests. Deloy, Reinartz, and Schnell are Silent Keys. The calls 2AGB, 2CGK, and W9GA have been reassigned. The last clue is the present G2JL, still listed in the *Callbook*. Is the present license holder the operator of 2JL in 1923? I sent an air mail letter off to G2JL posing this question. So far, no reply has been received. I guess we'll have to wait a few more months to see if the October, 1923, contact is a valid contender for the first transatlantic QSO. Stay tuned in.

tuned loops for 160-meter reception

Interest in 160-meter operation has risen and fallen since the exciting days of 1923. As a result of the expansion of the band by the FCC a few months ago interest is reaching a new peak, with more and more stations coming on the band every day. Sad to say, a lot of newcomers give up in disgust at the racket they hear in their receivers: static, broadcast harmonics, and intermodulation, TV sweep oscillator QRM, and lots more.

Hams have grumbled about difficult receiving conditions on 160-meters for years — and a few of them have done something about it. One area of interest centers around the compact receiving loop antenna (**fig. 1**).

The small loop was very popular for general broadcast reception during the twenties but faded into obscurity, except for direction finding purposes, in the next few years.

The pattern of the small loop antenna resembles that of the dipole, being a figure-8 in the plane of the loop. The input resistance of the loop antenna is very low if the loop is small in terms of the wavelength. For typical receiving loops it is of the order of a few hundredths of an ohm. Moreover, because the area of the loop is small compared with the wavelength, loop pickup compared with that of a full-size antenna is greatly reduced. Receiving loops generally need from 15 dB to 20 dB signal "boost" before they can compare with a typical half-wave dipole antenna.

Why, then, use a loop? Mainly because the loop has two excellent signal nulls that can be used to knock down local signals, interference, or line noise. On DX signals the loop appears to be relatively nondirectional

because of the random polarization of the ionospheric-reflected signals. And because of the ability to virtually null out much local, manmade noise, the loop antenna can provide a superior signal-to-noise ratio in many circumstances.

In the case of natural static, if the null of the loop is aimed in the general direction of a storm the static level can be reduced substantially. On the West Coast, summer static seems to come from the central Canada areas, and placing a null of the loop in that general direction reduces bothersome static by several S-units.

Best of all, the tuned receiving loop can be rotated until it provides excellent rejection of those devilish signals from local TV receiver sweep oscillators that make reception miserable during the evening hours.

In order to be effective, the receiving loop must have an electrostatic shield about it to reduce coupling to the house wiring system — unshielded loops may provide good reception nulls as the handbook indicate, but when used indoors, as most loops are, they readily couple to the nearby electric wiring and pick up all kinds of unwanted noise directly from the power lines. The electrostatic shield helps prevent this.

A few experimenters have used loops for Amateur service on 160-meters, and the purpose of this article is to provide the reader with two proven designs that may be duplicated with a minimum of effort. The loops are worth their weight in DXCC QSL cards if serious 160-meter operation is desired. Remember, if you can't hear 'em you can't work 'em!

the W6GPY 160-meter loop

The W6GPY loop was designed pre-war and described in the April, 1938, issue of *QST* (**fig. 2**). The loop consisted of four turns of hookup wire spaced within an electrostatic shield made of 1-inch (inside diameter) copper tubing. The diameter of the loop was 20 inches. The loop was

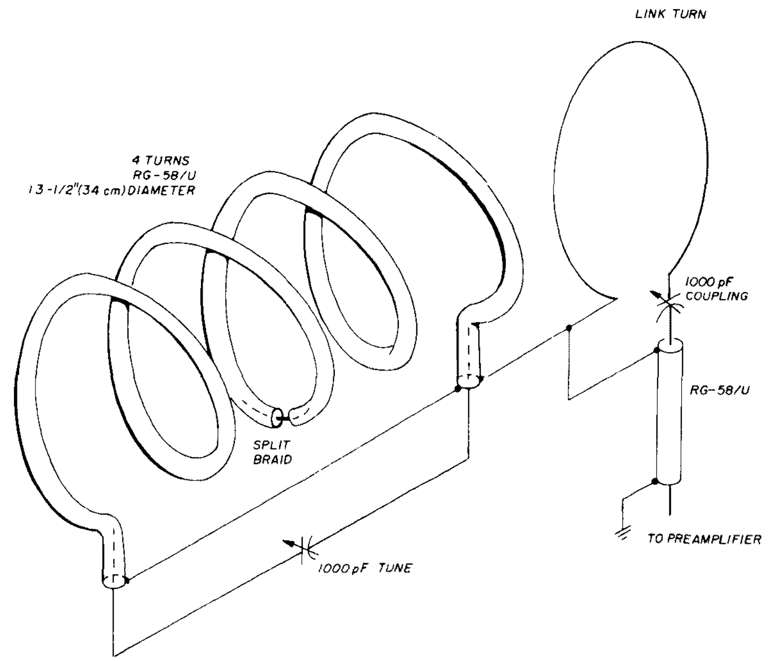


fig. 4. An oblique view of the W1FB loop as discussed in July, 1977, *QST* magazine. The loop is made of a 175-inch-long section of RG-58/U coaxial line. The shield braid is split at the center of the length and a section about 1-inch long removed. The line is then formed into a four-turn coil about 13-1/2 inches in diameter. The split *in the* shield is at the bottom of the coil, as are the connections. The outer braids are connected together as a common ground point and the inner conductor is tuned to resonance with a compression-type variable mica capacitor. A three-gang broadcast capacitor with a dial will provide a more comfortable tuning mechanism. The coax is formed into a four-turn coil and held in position with electrical tape. The pickup loop is made of insulated hookup wire and centered inside the coaxial coil. It is a good idea to tape the split braid at the center of the coil so a short does not occur at this point. The TUNE capacitor is adjusted for maximum signal strength. The COUPLING capacitor is decreased in value until a drop-off in signal strength is noted. Minimum coupling provides greatest loop selectivity.

tuned to resonance by a 350-pf capacitor and coupled to the receiver via a one-turn pickup coil and a low impedance, balanced transmission line. One end of the copper shield was insulated from ground to prevent shorting out the loop.

As for operation, the original W6GPY article said, "Loop antennas have very broad tuning characteristics when turned to the maximum signal, but are very sharp when turned to the minimum signal position. This means that the sharp minimum can be placed on a interfering signal or noise, and the broad maximum will allow the desired signal to come through."

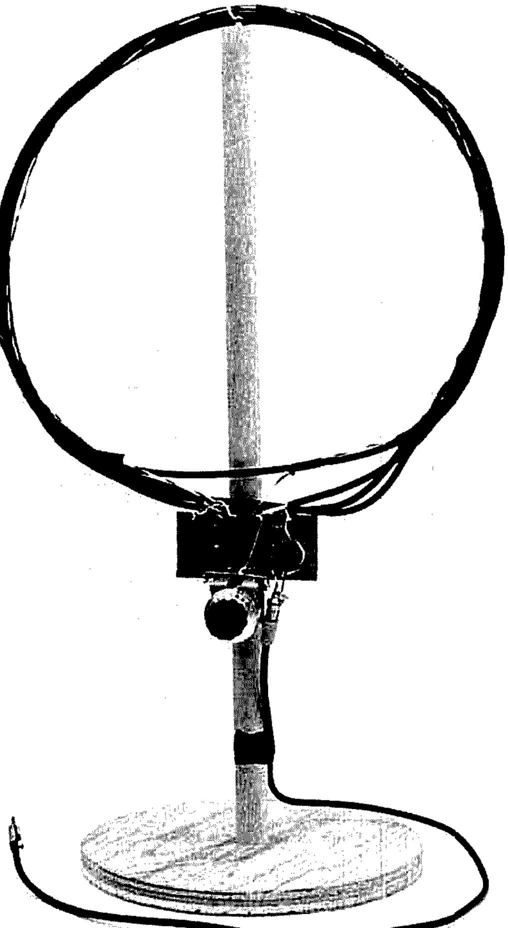


fig. 5. The "quick-and-dirty" version of the W1FB 160-meter receiving loop. Loop consists of four-turns of RG-58/U coax with a one-turn pickup loop made of hookup wire. Shield of coax line is broken at the center of the loop for 1 inch. The loop is resonated by a 500-pF capacitor (350-pF variable in parallel with 150-pF fixed). Series capacitor was replaced with fixed capacitor when correct degree of coupling to preselector was determined. Loop stand is made of wood dowel rod and circular plate cut from plywood. Assembly time — about an hour. Compact loop sits atop receiver.

The coming of war and cessation of Amateur activity in 1941 brought experimentation to a close and the subject of loops lay relatively dormant until the DX possibilities of the band were again explored between 1960 and 1965. My good friend W6PO had erected a 160-meter loaded groundplane antenna and found to his dismay that while it was a "bear-cat" for transmission, it was nearly useless for reception — all he could hear was noise.

Remembering the W6GPY article, Bob built up a shielded loop (**fig. 3**) that is still in use today at W6SAI. To boost the gain of the loop, a small preamplifier was added between it and the receiver. Loop *Q* is quite high and the background noise peaks sharply as the loop is tuned through resonance. With the values given, the loop tunes from 1.4 MHz to about 3.2 MHz. The *Q* of the loop and the selectivity of tuning are poor above about 2.8 MHz.

The loop works extremely well sitting atop the receiver. The passband to the −3 dB points is about 20 kHz, so the loop must be accurately tuned for best signal. Null rejection is excellent and a S9 + 40 dB racket from a local TV receiver sweep oscillator can be knocked down to the noise level of the system, which registers about S4 during the summer, daylight hours. As expected, the "nose" of the loop is quite broad and, for most reception, the loop plane is left in an east-west position.

I used the loop for many months until W6PO started to make noises that he might want the loop back. So I decided to build my own receiving loop.

the W1FB receiving loop for 160 meters

The idea of bending copper tubing into a circle didn't appeal to me at all. Surely there must be a simpler way of building a shielded loop! Somewhere in the back of my mind I remembered a recent *QST* article about a 160-meter loop. A quick look through the

yearly indexes of *QST* seemed to reveal nothing. Finally, I started looking through the magazines issue by issue. I found what I was looking for in my July, 1977, issue of *QST*. The cutesy title, which was cryptic to me, was "Beat the Noise With A Scoop Loop." This excellent review of the W1FB loop experiments disclosed a simple, shielded loop made of coaxial cable. Fig. 4 shows the *electrical* circuit of the loop, and a quick and dirty homemade replica of the loop is now in use at W6SAI (shown in fig. 5).

Thrown together in one afternoon, the W1FB loop performed nearly as well as the more complex W6GPY loop. Loop gain of the coaxial cable loop was somewhat lower than that of the bigger "copper tubing" loop. Bandwidth of operation was the same when the coupling capacitor was properly adjusted (approximately 350-450 pF). Rejection of signals at right angles to the plane of the loop was excellent. The only problem with this haywire loop was that it was self-supporting and after a few days the cable would droop and the loop would resemble a squashed hula-hoop. It was necessary to knead the cable back into the resemblance of a circle, at least for the esthetic value!

Earlier articles on receiving loops had stressed that the capacitance between the loop and the shield be held at a minimum for best results. The capacitance per foot of RG-58/U cable is quite high, so a second loop was built using low-capacitance RG-62/U cable. No appreciable difference in performance could be noted when the second loop was properly adjusted, so it would seem that the W1FB loop is satisfactory as is.

the loop preamplifier

Either loop design provides signals to the receiver that are about 15 to 20 dB below that provided by a good, outdoor antenna. Accordingly, a good, low-noise preamplifier having a gain of about 20 dB is required. A representative preamplifier is shown in the DeMaw article, or several are available on the market. The unit I used was the inexpensive AMECO PLF-2 picked up at a local flea market. Other suitable units are made by MFJ and Palomar.

using the receiving loop

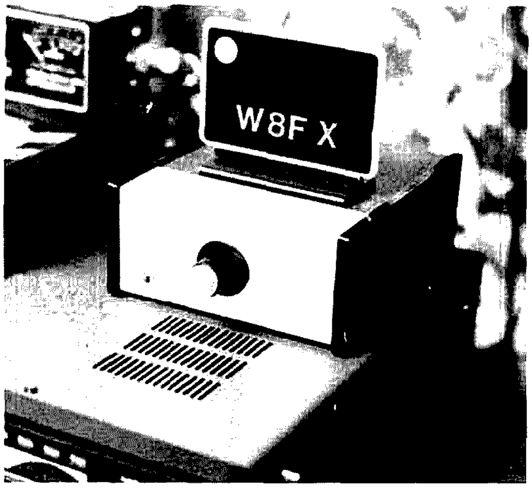
It's easy. Tune the loop and preamplifier for maximum background noise. Adjust the position of the loop for maximum rejection of line noise, or TV sweep oscillator noise. Or, if noise is not a problem, adjust the loop for strongest received signal. As I said before, the loop pattern is extremely broad and the rejection null very sharp. It won't take long to adjust yourself to the operation of this valuable 160-meter accessory.

Don't overcouple the loop to the preselector or you will find it difficult to achieve loop resonance and loop tuning will interlock with preselector tuning.

other solutions to the receiving problem

The simple loop seems to be a popular receiving antenna for 160 meters. Some experimenters have tried a long wire (300 to 1000 feet) spaced a foot or two above the ground. Others have tried the more complex long-wire Beverage antenna. Many 160-meter DXers have a variety of receiving antennas, selectable at the rotation of a switch. A lot depends upon your local noise level. During the past summer, the 160-meter receiving test that seperated the men from the boys was the ability of W6s to hear the transmissions of ZD8TC on Ascension Island through the local QRN level. Both loop designs provided readable signals, whereas ZD8TC was uncopiable on a high, outdoor horizontal antenna. Reception of ZD8TC on a large ground plane was possible, at good signal strength, but the *readability* was much better with the small loop antennas, sitting atop the station receiver!

ham radio



Clegg AB-144 "All Bander" atop author's KLM-2700 2-meter transceiver. The KLM-2700 directly tunes 10 meters by means of an internal OSCAR receiver, so the AB-144 isn't necessary for 10-meter fm reception. The AB-144 up converter is used here to continuously receive 100 kHz to 30 MHz on the KLM-2700.

listening in on 10 fm

Tips for getting in on the action: 10-meter fm comes alive

Ten-meter fm activity, particularly in familiar 2-meter repeater style, is growing by leaps and bounds. The trend to 10 fm is encouraged by several factors, including the current sunspot peak, which makes 2-meter-type repeater DXing super fun, and the availability of several frequency-synthesized commercial fm transceivers, such as the Comtronix and the Azden PCS-2800.

I considered it a bit late in the sunspot cycle to get aboard with a major investment in another operating mode, yet I wanted to hear what was going on in this hitherto unknown portion of the 10-meter band (29.5-29.7 MHz). This led me to investigate several practical, low-cost methods of fm reception, which I'd like to share with others.

the KLM 2700

I have a KLM 2700 multimode fm transceiver, which has an internal 10-meter OSCAR receiver. I found it would receive 10-fm signals very nicely. The KLM radio has fairly low sensitivity on 10 meters. It's adequate for OSCAR satellite reception in the 29.3-29.5 MHz range but not spectacular. I found that the OSCAR receiver would, in fact, tune the *entire range* of 27-30 MHz, which includes the 27-MHz CB band as well as the so-called (and illegal) CB/HF range between the 27-MHz CB and Amateur 28-MHz bands.

Since sensitivity was low, I added a *Hamtronics* P9 preamplifier at a kit cost of only $12.95. This two-stage, grounded-gate preamplifier uses the new family of Siliconix super FETs, originally designed for UHF service. It produces a gain of 20-30 dB with a noise figure of 1.5-2 dB. The sensitivity on 10 meters was truly astonishing. I tucked the small PC board into a corner of the transceiver near the 10-meter antenna coax input connector on the rear apron and

By Karl Thurber, W8FX, 317 Poplar Drive, Millbrook, Alabama 36054

connected the board to the nearest 12 Vdc point. Simple? You bet!

The KLM 2700 radio is primarily an fm rig, so all that's necessary to demodulate 10-fm signals is to set the transceiver to one of the two fm modes (narrow or wideband), and tune the VFO to the proper frequency. Since the 10-meter receiver was intended for OSCAR reception only, direct-readout 10-meter dial calibrations are not provided. You must make a conversion chart or logging table to cover the 10-meter band.

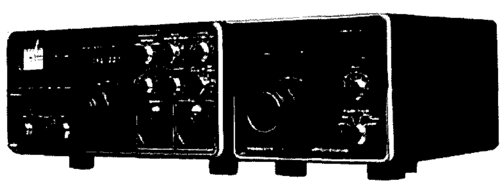
It happens that the repeater band, which straddles 29.5-29.7 MHz, is found at VFO dial settings between 145.95 (29.5 MHz) and 146.15 (29.7 MHz); the popular 29.6-MHz simplex, or calling, frequency is found in the center of the range, at 146.05 MHz.

You can also tune the four repeater channels (29.520-29.580 MHz input or 29.620 MHz-29.680 MHz output) by switching to the synthesized, digital-readout mode and cranking through this range in 20-kHz steps.* This sounds very complicated, but as any KLM 2700 owner knows it's really simple. Needless to say, 10-meter fm reception is superb on the very slightly modified KLM.

the TS-700S

An alternative route I followed in gearing up for 10-fm reception involved using a Kenwood TS-700S multimode transceiver in conjunction with a Clegg AB-144 "All Bander" up converter. The TS-700S, like the KLM 2700, is capable of first-rate 10-fm reception. This is made possible by the AB-144, which receives signals in the low-frequency, medium-frequency, and high-frequency ranges (100 kHz-30 MHz) and *up converts* them to one of the four, 1-MHz, 2-meter ranges of the TS-700S. I've found this unit to be absolutely outstanding for general-coverage SWLing and broadcast-band DX chasing without a separate communications receiver. With the up converter, all-band reception performance is limited only by the quality of the 2-meter transceiver with which it is used — and the TS-700S is an excellent multimode rig.

One corner of author Thurber's station. The Clegg AB-144 "All Bander" up converter, shown immediately above the FT-221R transceiver, tunes the fm portion of 10 meters. Above the AB-144 is a digital-frequency readout unit for the transceiver. Author's callsign placard sits on top. Although the article describes the use of the Clegg AB-144 with the Kenwood TS-700S transceiver, the AB-144 works well with the Yaesu transceiver and should work equally well with other fm or multimode 2-meter rigs for 10-meter fm reception.



The TS-700S 2-meter transceiver and 700S remote VFO. Author Thurber uses the Clegg AB-144 "All Bander" up-converter with this rig for low-frequency, medium-frequency, and high-frequency reception, and specifically to receive the 10-meter fm segment (29.5-29.7 MHz). The zero-center fm tuning meter and squelch control on the TS-700S are fully operational using this method.

To receive 10-meter fm, the AB-144 converter is set to the 26-30 MHz range, the TS-700S bandswitch is cranked to the 147-MHz range, and the transceiver is tuned between 147.5 and 147.7 Mhz, corresponding to 29.5-29.7 MHz in the 10-meter band. Good use can be made of the zero-center fm tuning meters and the squelch controls, which are fully operable on 10 meters on both transceivers. The TS-700S also has a built-in 2-meter preamplifier, which can help in pulling in weak fm signals by acting as an extra stage of i-f amplification. I've also used this arrangement with a Yaesu FT-221R transceiver with equally good results.

Another possibility, one I haven't tried, is to use a 10-meter converter such as the *Hamtronics* CA28, to up-convert the 10-meter band to 144-148 MHz. In conjunction with a multimode transceiver, complete 10-meter-band reception would, of course, be available — not just the fm segment.

*10-fm repeater spacing is 20 kHz, and offset is 100 kHz. Four channel pairs are available for us. Simplex channels are 29.500 and 29.600 MHz.

Author's CB coaxial vertical antenna from Radio Shack gave a good account of itself on the 27-MHz CB band, Amateur 10-meter SSB and CW band, and on 29.6-MHz Amateur fm. It has since been replaced by a Cushcraft fm Ringo for optimum 10-meter performance.

antennas

Ten-meter receiving antennas are by no means critical. For two years I used a Radio Shack CB-style coaxial vertical antenna for all 10-meter work until it bit the dust in a recent household move. It was replaced by a Cushcraft AR-10 10-meter fm Ringo, a very attractive end-fed halfwave vertical antenna designed to resonate at 29.6 MHz. This antenna provides a very flat, 1:1 match to 50-ohm coax by means of a 10-inch (25.4-cm) diameter tuning-ring assembly and a coaxial stub matching device. The 3.75-dB-gain antenna can also be used on other portions of the 10-meter band. Somewhat less-expensive CB versions, the CR-1 and CX-1000, are also available.

The Amateur 10-meter band is truly fascinating (not to speak of the freaky illegal "CB DX band" just above 11 meters). I have given some ideas for getting in on the action with today's Amateur transceivers and some peripheral equipment. Now you're on your own. Who knows how long the present propagation conditions will last?

ham radio

phantom-coil VXO

An artificial transmission line creates the illusion that a variable capacitor is the large variable coil required by a low-frequency VXO

The unit described here is used to replace the VFO in transmitters. In this application the VXO has high frequency stability and very small warmup drift.

Another application is to employ the VXO as a local oscillator for a direct-conversion receiver; such a receiver would have near crystal stability, so could give really useful reports on the frequency stability of incoming signals. Of course, the same VXO could also be used for transmitting if a dc transceiver were desired. A heterodyne arrangement where the VXO beats against a switch-selected set of crystals would have the advantages that a) stability would be better because both oscillators run continuously; b) break-in could be had by keying the mixer; and c) the frequency offset between transmit and receive could be obtained by switching capacitance across the appropriate crystal in the set. (I intend to produce a transceiver of this type for a QRP portable.)

A third possibility is the use of a VXO for the high-frequency oscillator in an fm receiver. This system would be virtually drift-free without the disadvantages of AFC systems.

types and characteristics of VXOs

The frequency of a crystal oscillator may be shifted over a restricted range by connecting variable reactances in series with the crystal. Since the frequency stability will decrease with frequency range, the designer must know the relationship between stability and range to arrive at a satisfactory arrangement for the intended application.[1] The CVXO, using variable capacitance only, always operates above series resonance for the crystal and is nearly as stable as a fixed crystal oscillator. But even with the greatest care in circuit design,[2] it is not possible to exceed a range of about 5 kHz on 40 meters if standard crystals are used.

On the other hand, the LVXO, using the equivalent of a variable inductance, can exceed a range of 50 kHz on the same band, but the stability will decrease with range as shown in **fig. 1**. Here the definition of stability is the percentage change in load reactance required to produce a given percentage change in frequency; it is shown in relation to a similar measure for the common LC oscillator. (By comparison, the CVXO is always at least 1000 times more stable than an LCO.) Also shown in **fig. 1** is the enormous inductance required to shift the frequency. The LXVO always operates below f_s, the series-resonant frequency of the crystal. Typically, f_s for 40-meter HC6/U crystals is 2 to 3 kHz below the frequency of operation with a 32-pF load capacitance; crystals may be ordered for specified values of f_s.

It is usual to obtain an effective variable inductance by connecting a large fixed inductor in series with a large variable capacitor. The minimum reactance of the capacitor must be small compared with the inductor's reactance, and its maximum must be equal to that of the inductor. This arrangement has a number of disadvantages:

1. A good coil must be inconveniently large mechanically on 7 MHz and lower frequencies

2. As a result of the large inductance, the self-resonance of the coil will be too close to the operating frequency, which will reduce the stability of the coil.

3. Because, near series resonance, the net reactance is the difference between two *large numbers*, the stability may be expected to suffer.

By Frank W. Noble, W3MT, 10004 Belhaven Road, Bethesda, Maryland 20034

4. Bizarre capacitor plate shapes are required to obtain reasonable frequency linearity.

reactance inversion

An improved tuning arrangement employs the reactance inversion properties of transmission lines. Consider an ideal line of characteristic impedance, Z_0, ¼ wavelength long, and terminated at the receiving end with a variable capacitor, C_T. According to Terman,[3] the impedance presented to the transmitting end is

$$Z = \frac{Z_0^2}{Z_T} = Z_0^2 j\omega C_T \equiv j\omega L_p \qquad \textbf{(1)}$$

where L_p is an equivalent or "phantom" inductance of value

$$L_p = Z_0^2 C_T \qquad \textbf{(2)}$$

Apparently the line has "inverted" a variable capacitance to a variable inductance. It is evident that L_p is linearly related to C_T, varying from the origin with a slope of Z_0^2. We may in theory adjust Z_0 to whatever value we please to obtain very large values of L_p for reasonable values of C_T. However, Z_0 for coaxial lines will not usually exceed 100 ohms, which is too small for our purposes. Also, real lines are very inconvenient mechanically on 40 meters.

Perhaps the simplest artificial line[4] is one-half of a "halfwave filter"; it consists of a single low-pass pi section with all reactances numerically equal at the operating frequency. Terminating this circuit with C_T as before, we have the circuit of **fig. 2**. Dispensing with the j operator, it is readily shown that

$$Z_1 = -\omega L \qquad \textbf{(3)}$$

and

$$Z_2 = \frac{\omega L}{\frac{C}{C_T} + 1} \qquad \textbf{(4)}$$

so that

$$Z = \omega \frac{L}{C} C_T \equiv \omega L_p \qquad \textbf{(5)}$$

from which

$$L_p = \frac{L}{C} C_T \quad \text{again the "phantom."} \qquad \textbf{(6)}$$

Note that L/C corresponds to Z_0^2 for a real line, but that it can have much larger values than are usual for coaxial lines. In contrast with real lines, the values of L and C for the "quarter-wave filter" are not independent. In every case

$$LC = \omega^{-2} \qquad \textbf{(7)}$$

so that

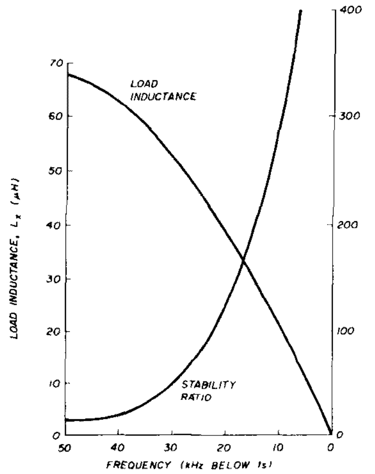


fig. 1. The LXVO can exceed a tuning range of 50 kHz on 40 meters, but the stability will decrease with range. Left-hand ordinate, equivalent load inductance versus frequency shift below crystal series resonance, f_s. Right-hand ordinate, stability ratio of the LVXO with respect to an LCO versus frequency shift below crystal series resonance. (HC6/U crystal, 40-meter LVXO. $C_0 = 6\,pF$; $r = 250$.)

table 1. Crystal list. All crystals are partially plated fundamental AT cuts, type HC6/U, specified for series-resonant frequency. (Available from JAN Crystals, 2400 Crystal Drive, P.O. Box 06017, Fort Myers, Florida 33906.)

crystal	frequency (kHz)
Y1	7010
Y2	7020
Y3	7030
Y4	7040
Y5	7050

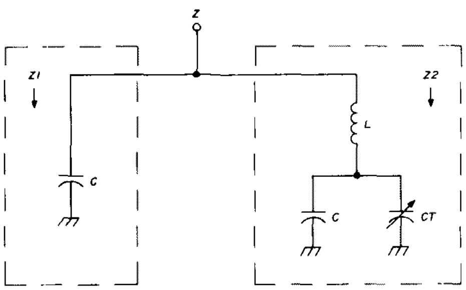


fig. 2. Circuit for an artificial quarter-wave transmission line terminated in a variable capacitor.

$$\frac{L}{C} = (\omega L)^2 = \frac{L_p}{C_T} = \frac{1}{(\omega C)^2} \qquad \textbf{(8)}$$

whence

$$L = \frac{1}{\omega}\sqrt{\frac{L_p}{C_T}} \text{ and } C = \frac{1}{\omega}\sqrt{\frac{C_T}{L_p}} \qquad \textbf{(9)}$$

From **eq. 6**,

$$C = \frac{L}{L_p} C_T \qquad \textbf{(10)}$$

Also from **eqs. 6** and **8**,

$$Z_0 = \omega L = \frac{1}{\omega C} \qquad \textbf{(11)}$$

where Z_0 is the characteristic impedance of the quarter-wave filter.

design example

We require an LVXO giving continuous coverage of the lower 50 kHz of 40 meters, and having a frequency stability at least 100 times better than an LCO. From **fig. 1** we find the maximum deviation for this stability is about 16 kHz. For convenience, we elect to reduce the deviation to 10 kHz, where the stability ratio is about 200; *i.e.*, about a fifth of the stability of a fixed crystal oscillator.

Also from **fig. 1** we find $L_x = 35.6\ \mu H$. To this must be added more inductance to cancel the reactance of the circuit to the right of Y_1 in **fig. 3**. Neglecting small effects,[5] the oscillator "looks" like the series combination of the coupling capacitors; *i.e.*, 110 pF. The additional inductance is 4.7 μH. Therefore, the inductance must range from 5 to 40 μH, approximately.

We arbitrarily assign $C_{T_{max}} = 245\ pF$. Then from **eq. 9**, $L = 9.16\ \mu H$, and from **eq. 10**, $C = 56.1\ pF$. The minimum value of C_T is that required to make $L_p = 5\ \mu H$, to cancel the input capacitance of the oscillator; $C_{T_{min}} = 31\ pF$.

The tentative design for the oscillator is given in **Fig. 3**. Note that we may include the left-hand C in the variable capacitance to save a part and to provide some additional inductance range to accommodate variations between crystals. (A semi-circular-plate, 365-pF air variable will be used in the final design to provide some latitude at both ends of the nominal range and to avoid the nonlinearities that occur near the extreme positions of a variable capacitor.)

inductance

By far, the most important consideration in this design is the quality of the pi-section inductance, since the filter uses air capacitors, and the oscillator input capacitors can be excellent (air, polystyrene, silver

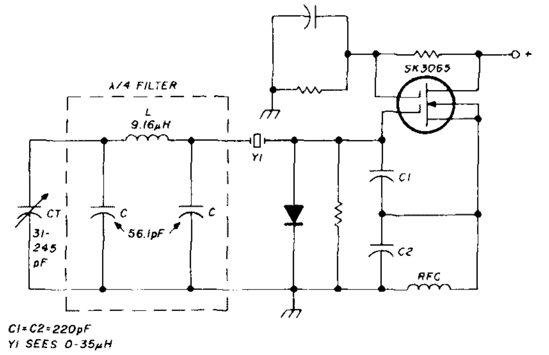


fig. 3. Tentative circuit for a VXO using an artificial quarter-wave line to transform a variable capacitor to a "phantom" variable inductance. The crystal "sees" an inductance that is variable continuously from zero to 35 μH by means of C_T. Omitting the left-hand C, the variable capacitor must have the range 87-301 pF approximately.

mica, etc.). The inductance requirements are:

1. Low distributed capacitance, so self-resonance will be far above 7 MHz. For a given coil quality, the higher the self-resonance the more stable the coil will be. A long, slim, close-wound coil is desirable for this property.

2. High Q, so that the oscillator coupling capacitors can be large. The larger the coupling capacitors, the less effect their instability will have; more important, since they shunt the transistor, larger capacitors will reduce the effects of drift in the transistor capacitances and conductances, as is the case with the Clapp circuit. High Q and low distributed capacitance are not compatible; the latter is probably more important.

3. Small physical size, so that the field of the inductance can be contained within shielding of reasonable size.

4. Mechanical rigidity.

5. Small temperature coefficient. This requriement will be less important if the heat dissipated within the cabinet can be minimized and isolated from the coil.

In particular, any kind of ferrite or iron-core coil is to be avoided because the temperature coefficient will be poor, and the inductance may vary with signal level. The machine-wound B&W *Miniductor*™* coils are probably the best choice. Their chief drawback is

*Miniductor is a registered trademark of Barker and Williamson.

that they are very hard to cut apart without special equipment. I used an electrically heated razor blade *at 100 watts*. Even with this, the tendency is to come out short on turns because the end turn loosens from the heat.

I had on hand a B&W No. 3008 *Miniductor*, which is 5/8 inch (16 mm) diameter. It was cut at 35 turns, giving a finished length of 1-3/32 inches (27.8 mm). The formula inductance is 8.7 μH, and its self-resonance measures about 65 MHz. The calculated inductance at 7 MHz is about 8.8 μH, somewhat below the design value of 9.16 μH. (The effect of switch and socket capacitance, which I did *not* consider, is to reduce L_x — so, for once, I erred in the right direction.) Going back through the math, C becomes 58.3 pF and the variable ranges from 89 to 303 pF. The "characteristic impedance" of the finished "quarter-wave filter" is about 388 ohms.

final circuit

Referring to **fig. 4**, the transistors are all dual-gate MOSFETs, RCA SK3065 or equivalent. For Q1 we need a) low input capacitance and conductance so that transistor drift will have little effect, and b) high transconductance so that the coupling capacitors can be large, immunizing the circuit to transistor drift and minimizing the additional inductance mentioned above. The diode clamps the positive maximum of the signal slightly above ground, stabilizing the amplitude and the transistor input capacitance.[6] The second gate provides a convenient means of controlling gain.

For Q2 we need effective buffering and low output impedance to ensure stability of the following stage. For effective buffering, the very low input capacitance and conductance of the MOSFET is desirable; and, since the output impedance varies inversely with transconductance, the high g_m of the SK3065 gives it an advantage over the more commonly used JFET; the cost is comparable. This stage is direct-coupled to the oscillator, saving two parts. Since the dc component at the Q1 source is small, we simply increased the Q2's source resistor to compensate.

For Q3, we need additional buffering and voltage

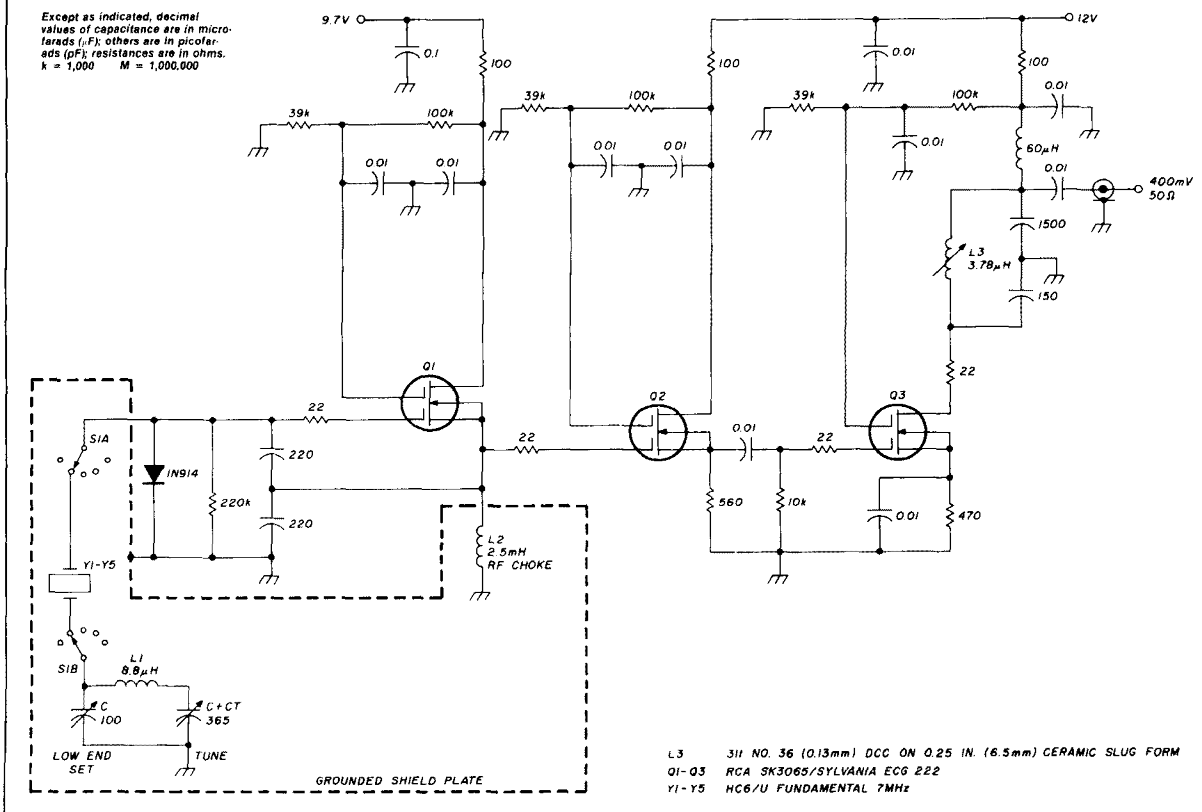


fig. 4. Author's design for the "phantom-coil" VXO, which is a first model to test the theory. Improvements are suggested in the text. Data for crystals Y1-Y5 appear in table 1.

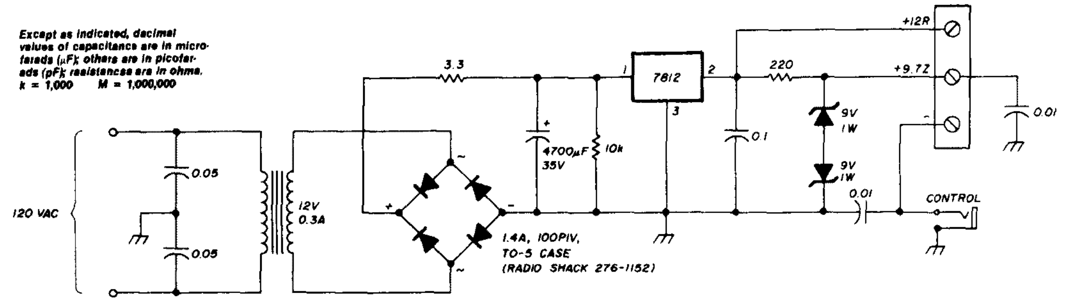


fig. 5. Power supply for the VXO. It was built in a separate enclosure to isolate the VXO from vibration and heat.

gain, $g_m\ Q\omega L$. Since the frequency range is small, it is hardly possible to get a too-large Q in the physically small output coil (Q must not exceed 140). The large drain resistance of the FET shunts the coil very little, and the large transconductance gives the device large voltage gain. In addition, the bypassed second gate reduces gate 1 to drain capacitance, tending to stabilize the stage and to isolate the output from the oscillator. The output circuit is a lowpass filter having an impedance transformation of about 100, providing a reasonable match of the transistor to 50-ohm coaxial cable. Q3 provides about 400 mV into 50 ohms.

power supply

Current requirement is small, so an ordinary zener regulator would suffice. However, the 7812 IC is inexpensive and offers better regulation, reduced ripple, and thermal shutdown. See **fig.** 5. The oscillator stage is supplied by a zener regulator of unusual type.[7] Since the temperature coefficients for zener and forward conduction are of opposite sign, the back-to-back connection of the two 9-volt zeners should have better temperature stability than a zener alone — and produce about 9.7 volts because of the forward drop in the lower diode. The shorting phone jack labeled **control** activates the oscillator from an external switch for spot and send functions.

mechanical details

The oscillator enclosure is a Bud cabinet No. AU-1029, measuring 4 by 5 by 6 inches (10 by 12.7 by 15 cm). The cover plates were replaced with 1/8 inch (3 mm) aluminum to stiffen the assembly. All parts were attached to the front panel using spacers where necessary. The crystals and other frequency-determining parts were separated from the amplifiers by a grounded shield plate; the oscillator leads were passed through small holes in the shield. The output coil is partially shielded by its mounting bracket and is physically separated, as far as possible, from the oscillator. The rf-output and power-supply leads pass through the back plate and are firmly held by a Romex™ clamp.

The power supply is housed in a small minibox separated from the main chassis. Elaborate bypassing and shielding are necessary to minimize rf pickup since the oscillator runs at very low level.

performance

To check the frequency stability, the setup shown in **fig.** 6 was used. The offset between VXO and the crystal standard was adjusted to exactly 120 Hz, as shown by the butterfly Lissajous figure produced by the mixer output *versus* the power-line frequency. (Except for occasional phase shifts, the 60-Hz line frequency may be considered absolute.)

The offset is desirable because it tends to reduce pulling effects, that is, the tendency for the oscillators to synchronize. The pattern will rotate at the difference frequency, and the rotation will be smooth in the absence of pulling.

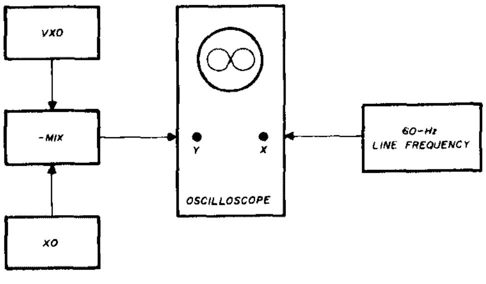


fig. 6. Block diagram of author's setup to test frequency stability of the VXO. Test procedure is described in the text.

The beat between the oscillators generally holds to within about 5 Hz over a one-hour period when both are stabilized. Since this is probably as good as the crystal standard, I conclude that the phantom-coil VXO is about on par with ordinary crystal oscillators.

The start-up drift of the VXO, measured against a stabilized standard crystal, is so small as to be unmeasurable with this scheme.

suggested improvements

The unit described here is a first model built to test the theory. Among the improvements to be considered are:

1. Increase the value of C_T so that an even smaller coil could be used. The ideal coil for 40 meters is about 6.25 μH, requiring $C = 82$ and $C_T = 526\ pF$ respectively. Allowing for some overlap, C_T should be a semi-circular-plate variable capacitor of about 640 pF — a part difficult to acquire.

2. Use the smaller B&W No. 3004 miniductor. This coil has better geometry for low distributed capacitance and is more convenient to use mechanically. The coil might be mounted more securely and placed farther from the shielding.

3. Double shield the oscillator and improve the buffering and bypassing. (This model is very sensitive to rf in the station.)

4. Place the output coil and choke in full shields. The fact that keying the output from open to short circuit produces measurable frequency shift means that the coupling between the output and the frequency-determining circuit is not as small as it should be. Link output might be preferable.

5. Use a larger cabinet, perhaps a 6-inch (15-cm) cube.

6. Use a low-ratio logging vernier dial.

I welcome communication with others who may wish to develop this idea further. Please include a self-addressed, stamped envelope with your comments.

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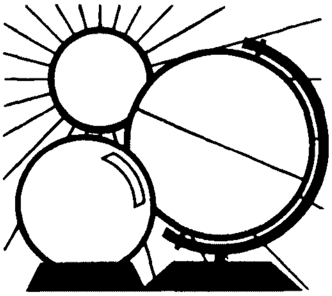

DX FORECASTER

Garth Stonehocker, KØRYW

last minute forecast

January is very similar to December in propagation and solar-terrestrial effects. The shortest days and the closest proximity to the sun come about at winter solstice, the last third of December. There is a normal lag in ionospheric effects, much like the lag in winter's tempeture averages, which are usually lower in mid-January than at December solstice. The ionosphere is a balanced energy system that takes time to adjust to seasonal changes. Thus we see a progressive but slow change month by month through the year.

The ionosphere demonstrates a fast steep rise in maximum usable frequency (MUF) along with the rising sun. The MUF reaches a high (sharply pointed peak) value just after noon, local time. It goes down after noon but not as steeply as it rose; the decay is a slower process than the build-up of ionization. If you're near the equator (± 20 degrees magnetic latitude), the MUF may remain high until late evening. This accounts for the excellent one-long-hop trans-equatorial propagation of the winter months. The propagation maximum is about 2000 local time and is enhanced by disturbed geomagnetic conditions of an A figure greater than about 25 or a K of 4.

The DX forecast for January is that, after a slow start the first week, the second and third weeks of the month should be very good on the higher frequency bands, returning to fair the last week. Solar flares may spawn a short geomagnetic disturbance around the 15th and 18th. Other disturbances may be observed in the first and fourth weeks, when the better DX is expected on the lower frequency bands. Remember, though, that a bit of disturbance, when the geomagnetic field is varying, moving the ionization around, gives paths to unusual DX for short periods (15-30 minutes). Stay in there even though signals may be weak and fading.

Lunar perigee is on January 8 this month. There will be an intense but short meteor shower lasting a few hours some time between January 2nd and 4th. It is known as the Quadrantid shower.

Are you a new ham that has discovered the thrill of DX with that new rig you got for Christmas, or an old ham that has taken time out from years of rag chewing for a renewed go at DX chasing? Either way, you may be interested in the fundamentals of propagation and rules of thumb that will help you put that signal where you want it. Through the year you'll get just that by watching this column, and you'll get a monthly forecast of propagation conditions too. It may not make you an ionospheric physicist or a communications engineer; but it will enable you to have some fun trying to do your own forecasting — or just keep you abreast of what's going on as you work DX. If you're really interested in current conditions and forecasts, try subscribing to the biweekly *HR Report*. If you're interested in more forecasting details, you may write to me at Route 1, Box 36, Earlysville, Virginia 22936.

band-by-band summary

Six meters will open occasionally for F2 long skip by the trans-equatorial one-long-hop propagation mode (TEM). The openings will follow the sun during the day and into late evening. Geomagnetic disturbances will enhance this mode, as will a high solar flux.

Ten meters will have openings more often and of longer duration than will six meters. The openings could be TEM or regular F2 long skip during the 27 days of solar flux maximums. In either case it is a good time to talk to our friends down under. Openings may favor southern Africa, South America, and Australia — particularly southern Africa.

January

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PST	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	
ASIA FAR EAST	15	20	40	40	20	20	20	20	—	—	—	—	—	—	—	—	—	20	15	15	10	10	10	10	N
EUROPE	—	20	20	20	20	15	15	15	15	15	—	—	20	20	20	20	40	40	40	40	—	—	—	—	NE
S. AFRICA	15	15	15	10	10	10	10	10	15	15	15	20	—	—	—	—	—	20	20	20	20	20	20	15	E
S. AMERICA	10	10	10	10	10	10	10	10	20*	20	—	—	40	40	20	20	20	20	15	15	15	15	10	10	SE
ANTARCTICA	—	—	—	—	—	—	—	40	40	40	40	40	20	20	20	20	20	20	20	20	20	20	15	15	S
NEW ZEALAND	10	10	10	10	15	15	15	20	40	40	40	40*	20	20	20	20	15	15	15	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	15	15	15	15	20	40	40	—	—	—	—	—	20	15	15	15	15	10	10	10	10	W
JAPAN	10	10	15	20	40	40	40	40	40	40	40	40	40	40	—	—	—	20	20	20	15	10	10	10	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
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EUROPE	40	20	20	20	15	15	10	10	15	15	20	—	—	—	—	40	40	40	40	40	20	20	40	40	NE
S. AFRICA	15	15	15	15	10	10	10	10	10	15	15	20	—	—	—	—	—	20	20	20	20	20	20	15	E
S. AMERICA	15	15	10	10	10	10	10	10	10	10	15	20	40	40	40	40	40	20	20*	15	15	15	15	15	SE
ANTARCTICA	—	—	—	—	—	—	—	—	—	—	20	20	20	20	20	20	20	20	20	20	20	15	15	15	S
NEW ZEALAND	10	10	10	10	15	15	15	15	20	40	40	20	20	20	20	15	15	15	15	15	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	10	10	10	15	20	—	—	—	—	—	—	—	—	—	—	—	15	15	10	10	W
JAPAN	10	15	—	—	—	20	40	40	40	—	—	—	—	—	—	20	20	20	20	20	20	15	10	10	NW
CST	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	

EASTERN USA

EST	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	
ASIA FAR EAST	15	20	—	—	—	—	—	20	20	20	20	20	—	—	—	—	—	—	20	20	15	15	15	15	N
EUROPE	20	20	20	20	20	15	15	10	10	10	10	15	40	—	—	—	40	40	40	40	40	40	20	20	NE
S. AFRICA	15	15	15	15	15	10	10	10	10	10	15	20	—	—	—	—	—	20	20	20	20	20	20	15	E
CARIBBEAN S. AMERICA	10	10	10	10	10	10	10	10	10	15	40	40	40	40	20	20	20	15	15	15	15	15	15	15	SE
ANTARCTICA	20	20	—	—	—	—	—	—	—	—	—	—	20	20	20	20	20	20	20	20	20	20	20	20	S
NEW ZEALAND	10	10	10	10	10	15	20	40	40	80*	40	40	40	20	20	20	20	20	20	20	15	15	15	10	SW
OCEANIA AUSTRALIA	10	10	10	—	—	—	10	10	15	20	40	40	—	—	—	—	—	20	20	15	15	15	15	10	W
JAPAN	10	15	20	—	—	—	—	—	—	—	—	—	—	—	—	—	—	20	20	20	15	15	15	10	NW

*Look at next **higher** band for possible openings.

Fifteen meters can have the same TEM modes as 6 and 10 meters. The openings should be frequent and long. Worldwide DX is prevalent from after sunrise until well after sunset, especially during the periods of high solar flux (listen to WWV at 18 minutes after the hour for reports on solar and geomagnetic conditions). A good practice when bands are open is to work the highest band that is open first, then drop down in frequency to catch each band until it closes.

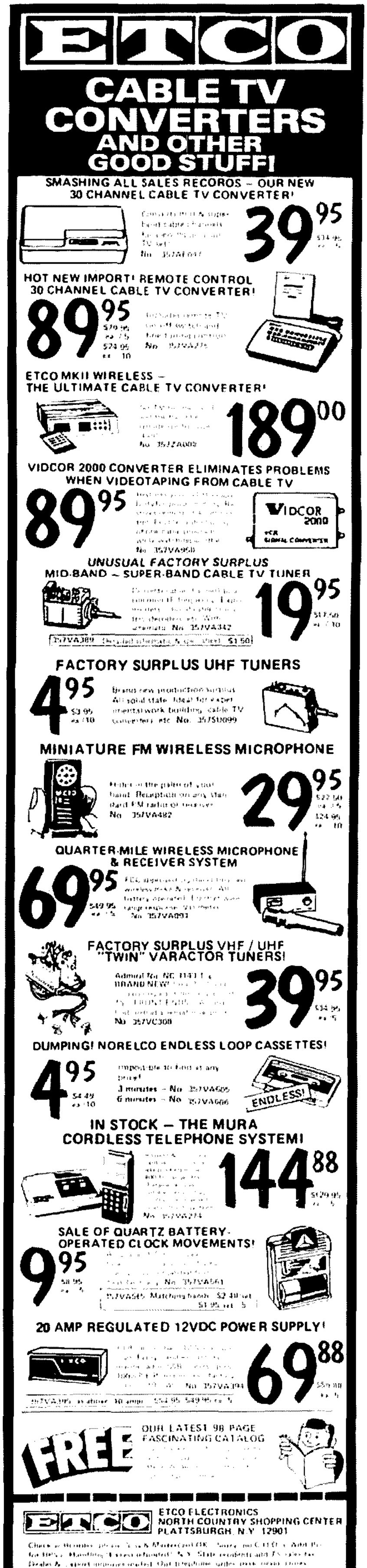
Twenty meters will be open most days and nearly through the night to some areas of the globe, with long skips of 1000-2500 miles and plenty of short-skip of 1200 miles near midday. Both propagation modes follow the sun across the sky: east, south, then west. This is the workhorse of the bands for DX as well as traffic handling.

Forty meters is the transition band into all-night propagation as well as some short skip during the day. Most areas of the world can be worked from darkness till just before sunrise. Hops shorten on this band to about 2000 miles, but the number of hops can increase since signal absorption is low during the night.

Eighty meters is traditionally a ragchewer's band but much DX work is also possible. The band operates much like 40 meters except that the hop distances shorten to about 1500 miles at night, and even shorter during the daytime. Noise from distance thunderstorms is so low as to make these bands a joy to work this time of year. The path direction follows the darkness across the earth (east, south, then west). Just wiggle in between the QRM.

One-sixty meters will be about like 80 meters, with reduced range to 1000 miles. It provides good DX for enthusiastic DXers. The new band power and areas should increase activity here, so we'll be listening. How about you?

ham radio



Coming Events

ACTIVITIES

"Places to go..."

FLORIDA: The Martin County Amateur Radio Association's annual Picnicfest, Hamfest, Saturday, January 30. 8 AM to 3 PM, Langford Park, Jensen Beach. Free admission. Picnic areas and children's playground available. For details: WA4GQY, Vern 305-334-6220. W4OST, Don, 305-286-0500. WA4GUH, Mike 305-334-6000 or 305-878-7111.

PLAYBOY CLUB: Plan ahead now to attend the ARRL Hudson Division Convention, October 30-31, 1982, at the Playboy Club, Great Gorge, McAfee, NJ. For info send SASE to HARC, Box 528, Englewood, NJ 07631.

ILLINOIS: The Wheaton Community Radio Amateurs Hamfest, Sunday, February 7, Arlington Park Race Track, Arlington Heights, NW of Chicago. Doors open 8 AM. Free flea market tables, hourly door prizes, special computer section. First prize: New Transceiver. Advance tickets $2.50; $3.00 door. Talk in on 146.94 and 146.01/.61. For info: SASE to Wheaton Community Radio Amateurs, P.O. Box QSL, Wheaton, IL 60187.

ILLINOIS: Wheaton Community Radio Amateurs Hamfest will be held February 7, 1982, at Arlington Park Race Track EXPO Center, Arlington Heights, Illinois. Free Flea Market tables and expanded floor space. Large commercial area including the new "computer" section. For commercial info call WB9TTE at 312-766-1684; for general info call WB9PWM at 312-629-1427. Clear paved parking. Awards. Tickets $3.00 at entrance, $2.50 in advance. Send SASE to WCRA, P.O. Box OSL, Wheaton, IL 60187. Talk-in on 146.01/61 and 146.94. Doors open 8 AM. Be There! — KA9KDC.

MICHIGAN: The 12th annual Livonia Amateur Radio Club's Swap 'n Shop, Sunday, February 28, 8 AM to 4 PM, Churchill High School, Livonia. Door prizes, refreshments, free parking, tables. Talk in on 146.52 simplex. Reserved table space available. For information SASE to: Neil Coffin, WA8GWL, Livonia ARC, P.O. Box 2111, Livonia, MI 48151.

SOUTH BEND, INDIANA Hamfest Swap & Shop, January 3, 1982, first Sunday after New Year's Day at Century Center downtown on U.S. 33 ONEWAY North between St. Joseph Bank Building and river. Industrial history Museum in same building. Half acre carpeted in one room. Tables $3 each. Four lane highways to door from all directions. Talk-in Freq: 52-52, 99-39, 93-33, 78-18, 69-09 and 144.83-145.43.

MICHIGAN: The Southfield High School Amateur Radio Club's annual Swap & Shop, January 17, Southfield High School, 24675 Lahser, Southfield. 8 AM to 3 PM. Admission: $2.00. Door prizes, food, parking. For information/reservation: Robert Younker, Southfield HS, 24675 Lahser, Southfield, MI 48034, (313) 354-8210.

MICHIGAN: The Oak Park Amateur Radio Club will hold a Swap and Shop, January 10, Oak Park High School, Oak Park Blvd., Oak Park. 8 AM to 3 PM. Admission: $2.00 PP. Under 12 free. Door prize, YL raffle, YL table, food, free parking. Talk in on 146.04/64 and 146.52 simplex. For information/reservation SASE: Rob Numerick, WB8ZPN, 23737 Couzens, Hazel Park, MI 48030. (313) 398-3189.

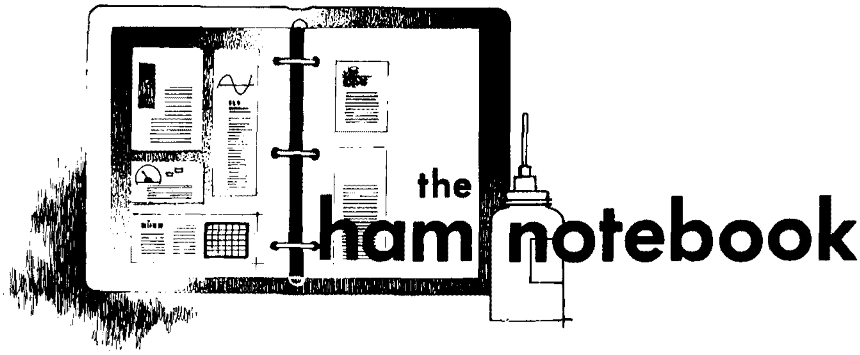
PENNSYLVANIA: Lancaster Hamfest, February 21, 1982 Guernsey Pavilion, Route 30 east of Lancaster. Admission: $3.00. XYLs and kids free. Doors open 0800. All inside spaces by advance registration only. Registration deadline, 10 February. Talk in on 146.01/61 or 146.52. For info: SERCOM, Inc., P.O. Box 6082, Rohrerstown, PA 17603.

TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums: air-conditioned exhibit area; large indoor/outdoor flea market. For more information: (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

OPERATING EVENTS

"Things to do..."

JANUARY 17: The Phil-Mont Mobile Radio Club Station W3TKQ will be celebrating its 30th anniversary and commemorating the Club's association with the Franklin Institute and the birthday of Ben Franklin, Philadelphia's First Citizen. Station will operate 80 through 10 meters from 8 AM to 8 PM. A special QSL card/certificate for a SASE. Frequencies lower edges of the General and Advanced bands.



inexpensive CW filter

A minimum-component-count, three-pole passive CW filter is shown in fig. 1. Surplus unpotted 88-mH toroids are used. Two of the inductors are tapped at the junction of two windings. The full value of the third inductor is also used. The filter characteristics are listed in **table 1** for different capacitor values.

I've built this filter using 0.47-μF capacitors and have been using it with my direct-conversion receiver for over six months. It provides an inexpensive way to improve receiver selectivity.

Frequency response (**fig. 2**) has been measured using a 600-ohm generator and a 605-ohm resistor as a termination. I found that the filter sounds better when terminated in an emitter-follower with approximately 600 ohms input resistance than when driving high-impedance phones directly. You might want to build two of these filters: one to provide a high passband and one to provide a low passband.

Values were calculated from the work of Rife[1,3] and Wetherhold[2] using a minimum-cost approach.

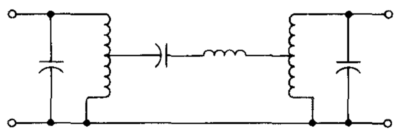


fig. 1. Passive CW filter: all three inductors are 88 mH. Three identical capacitors are used. See table 1 for characteristics.

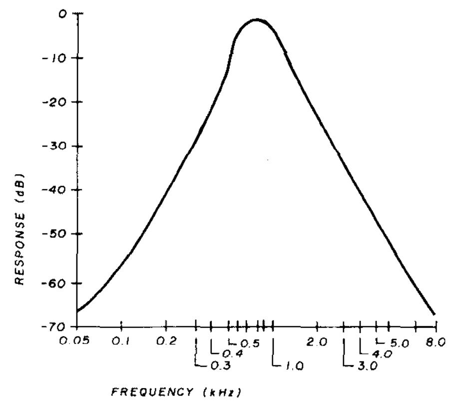


fig. 2. Response of the passive filter with 605-ohm resistive termination.

table 1. Calculated filter characteristics.

C (μF)	R (ohms)	bandwidth (Hz)	f_0 (Hz)	f_L (Hz)	f_H (Hz)
0.33	730	660	934	660	1321
0.47	612	553	783	553	1107
0.68	509	460	651	460	920
1.0	420	379	537	379	758
1.5	343	310	438	310	620

R = termination resistance
BW = 3-dB bandwidth
f_0 = center frequency $\sqrt{f_L f_H}$
f_L = lower cutoff frequency
f_H = upper cutoff frequency

references

1. D.C. Rife, WA2PGA, "Low-Loss Passive Bandpass CW Filters," *QST*, September, 1971, pages 42-45.
2. Edward E. Wetherhold, W3NQN, "Technical Correspondence," *QST*, January, 1972, page 56.
3. D.C. Rife, WA2PGA, "Technical Correspondence," *QST*, May, 1972, pages 56-57.

Jonathan Radovsky, WB1AFQ

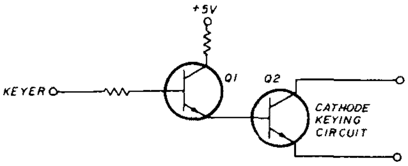
cathode keying with the Heath HD-1410

When World Radio Laboratories first produced the Meteor DSB 175 transmitter over fifteen years ago, we bought one. As in most of the equipment produced in those days, cathode keying was used. Because not many hams used electronic keyers then, this posed no real problem. Besides, the keyers that were in use were generally the tube type, so the current demands and voltages encountered in cathode keying were of little importance.

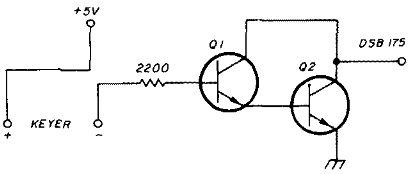
When the transistor finally made electronic keyers both affordable and commonplace they became, for many of us, almost essential pieces of equipment. Unfortunately, the voltage and current demands of the cathode keying circuits made it difficult to use the new solid-state keyers without buffering, usually with some sort

of relay. But the relay was generally bulky, often expensive, and hardly compatible with true QSK. The result was that much of this gear went quietly to the storage closet.

Realizing a need for a second CW position but lacking the funds for a whole new rig, we pulled the Meteor out of the closet and set about devising a way to key it with the HD-1410. We turned immediately to the *ARRL Handbook* for a suitable keying circuit and found this:



We soon found there's no way for this circuit to work with the 1410, since the keyer is just a switch. Consequently, all it does is connect Q1 base to ground, providing no voltage output. If you were to try this circuit, the frustration probably encountered would cause you to give up and to return your old transmitter to the back shelf of your closet. With a few minor changes, however, we produced a workable circuit adaptable to just about any keyer:



This circuit consists of a Darlington transistor, which uses the keyer to provide on-off bias, producing about 1.5 mA across the keyer. In fact, the power supply we used has no bleeder resistor, and the current drain is so low it will key the thing for several minutes after the supply is shut off, using the discharge current from the filter capacitors.

The cathode voltage-current values of the rig to be keyed will determine what you can use for Q2. We used an RCA transistor with a 300-V breakdown for the DSB-175, which should be sufficient for most rigs. The circuit is so small it can be placed inside most keyer cabinets, in a matchbox-sized cabinet, or permanently installed inside the old transmitter. Best of all is the fact that it allows the use of your favorite keyer with a fine old piece of equipment for less than what it will probably cost you for a relay.

David G. Boyd, K9MX and **Max Boyd, N9MX**

attaching PL-259 connectors to RG-58/U cable

If you use a lot of RG-58/U cable and PL-259 connectors, here's a much better way to connect the connector and cable. You'll need a special tool, the Buchanan C24, which is available from electrical-equipment supply houses.

1) Strip 25 mm (1 inch) of the cable insulation.

2) Slip the shield back over the outside of the cable wtihout unraveling the shield. Use a UG/176U adapter, which has a larger hole and much thinner walls.

3) Slide the adapter over the outside of the folded-back shield. Crimp with the special tool (Buchanan C24). Use just enough force to tighten.

4) Strip the cable center conductor about 6 mm (0.25 inch) from the adapter. This helps keep the solder from flowing too far into the PL-259, which could cause a short circuit.

5) Tighten the adapter into the connector. Solder the center conductor only.

This method of installation reduces the danger of wire "whiskers" shorting the cable, and it's fast and neat.

Felix W. Mullings, W5BVF

automatic repeater/ receiver sensitivity

Have you wanted a repeater to operate so that it will be somewhat desensitized until triggered? The circuit described here has been used commercially in a few applications, but I've never seen it used by Amateurs. One of the major problems with repeaters is that, being very sensitive (0.2-0.5 μV), they are prone to false triggering.

Fig. 3 is extremely simple. One of the i-f transistors must be chosen for purposes of changing sensitivity by changing the bias voltage of the base. In the G.E. Master Line (ER-41-C), I found that the high i-f transistor did the trick. R3 was fed 10 volts. The new circuit uses resistors R4, R5, R6, which compose a voltage divider. Potentiometer R7 selects a portion of the voltage depending on the setting of S2. With S1 in the normal position, 10 volts is fed to the receiver for maximum sensitivity. The relay operates with the transmitter on and changes receiver sensitivity to maximum with the transmitter on.

For example, suppose you decide to operate your repeater with a sensitivity set at 0.6 μV. A weak, varying

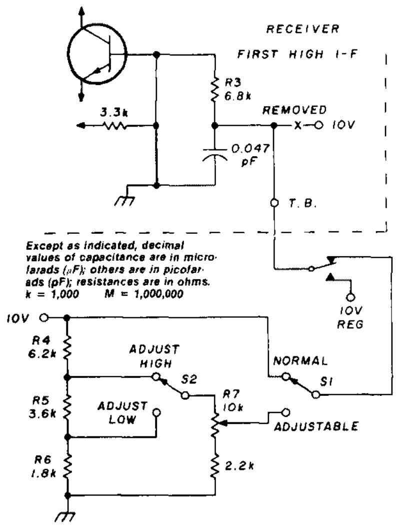


fig. 3. Simple circuit for desensitizing repeater receivers for weak input signals.

mobile signal might be coming in at 0.3 μV. It would not trigger the repeater until it reached 0.6 μV. If this signal faded, the repeater would stay at maximum sensitivity. It seems to me that, with the congested repeaters in some areas, this feature would be desirable.

Vern Epp, VE7ABK

metal cleaning with dip-type cleaners

Those who have occasion to clean brass, copper, silver, or gold may take advantage of some of the chemical cleaners that quickly strip surface oxidation. Numerous brand names are available. One is "e-z-est Jeweluster for Coins," formula H-907, from Products Research Company, Box 11115, Oakland, California 94611. Chemical dip cleaners can be obtained at coin dealers, silverware departments of larger department stores, and at some supermarkets. I purchased 142 grams (5 oz.) of the above product at a coin shop for about $2.

Either dipping the object into the liquid, or brushing it on in the case of larger surfaces, quickly strips surface oxides leaving the metal bright and shiny. It can then be soldered easily, or sprayed with protective acrylic varnish to prevent tarnishing. Take care in cleaning plated objects, however. Leaving the chemical on the metal too long will result in some surface metal loss. If in doubt, test a small area first. After cleaning, rinse the object thoroughly in running water to stop the chemical etching action.

Chemical composition may vary. However the active ingredient in the product mentioned is thiourea, $CS(NH_2)_2$, a chemical bleaching agent used in photography. Where large applications would make cost an important factor, it may be worthwhile to purchase thiourea from a chemical supply house. Above all, follow the manufacturer's instructions carefully.

Robert Wheaton, W5XW

NEW products

squelch tail eliminator

Circuit Electronics, Inc., introduces a new model tail chopper, model TC-2200. The board size is 1.75″ × 3.75″. It features temperature-compensated op-amps and digital logic, 6-dB sinad 10 millisec noise switch, maintains normal hysteresis, LED to indicate squelching, an on board 10-watt reed relay for the squelch.

Model TC-2200 can be connected to most repeaters to eliminate squelch tails. Also has squelch enable-disable function for the operation. The TC-2200 is a PC board assembled with instructions for repeater or mobile use. Model TC-2200 sells for $54.95.

For further information, contact: Ray L. Hruska, 621 Bishop, Salina, Kansas 67401.

voice controller

Remote control by voice via radio or telephone is now possible with the Covox Model I Voice Controller. Low cost and fully self-contained, this speaker-independent and noise-and-click-resistant system extracts the voicing component of speech from low-grade voice communication circuits in the same way a human listener does.

The primary measure of voicing duration is modified and corrected through cross-correlation with vowel sounds characterized by the spoken words *dih* and *dah*. Spoken Morse, Binary, or RTTY codes are reliably recognized with considerable tolerance of the particular speaker and voice channel quality. A 16-word vocabulary will control anything that can be switched: lights, a remote transmitter, garage doors, wheel chairs. Or use the fundamental pitch output for proportional control tasks, such as varying motor speed or dimming lights.

Priced at $389.00, the system comes complete with ac adapter, microphone, and users' manual. Contact Covox Company, P.O. Box 2342, Santa Maria, California 93455.

2.5-kW automatic antenna tuner

The Daiwa CNA-2002 marks a major advancement in antenna tuner technology with a compact, economical, and automatic 2.5-kW antenna tuner. The relatively small size of the CNA-2002 is made possible by a Daiwa breakthrough in high-voltage variable capacitor design.

The matching function of the tuner becomes automatic whenever the OPERATE button is pressed (5-50 watts of rf must be applied to the tuner). The internal detection circuitry detects forward and reflected power, and the resultant proportional dc voltage is applied to the motor-control amplifier which in turn drives the tuning motor. The tuning motor is connected to two variable tuning capacitors through a gear train using a 30:1 gear ratio. Automatic operation ceases when the SWR dips below 1.5:1. Two fine-tuning controls on the right-hand side of the CNA-2002 can be used to quickly lower the SWR to 1:1. The CNA-2002 performs its automatic tuning function in less than 45 seconds.

For more information, contact MCM Communications, 858 E. Congress Park Drive, Centerville, Ohio 45459.

power pocket

VoCom announced its latest addition at Radio Expo. For those who own the ICOM IC2A radios, they have developed a mobile mount called the Power Pocket® that incorporates some exciting new features.

First and maybe most importantly, the Power Pocket® contains an rf amplifier that will increase power output from several watts to 25 watts. The Power Pocket® also includes an audio amplifier and a big 4-inch speaker so that messages can be heard over road noise even when the windows are rolled down. Another benefit is that by using the Power Pocket® the IC2A's audio circuit can be run at significantly lower power for reduced battery consumption. But that's not all.

The Power Pocket® will charge the batteries in your IC2A! The spring loaded charger pocket accepts all ICOM power packs and ensures that firm positive contact exists for full battery charging. The charging function has an independent switch that allows you to charge the pack even if the amplifiers are turned off. Finally, the Power Pocket® contains a mic pre-amp that allows the IC2A to be used with either any standard mobile mike or the ICOM speaker/mike.

Units like the Power Pocket® are available for commercial service. Commercial users have found that the utility of their radio investment is significantly increased using units similar to VoCom's Power Pocket®. You will too if you pick up one of these units. Let the Power Pocket® add full mobile capability to your handheld IC2A. Contact VoCom Products Corporation, 65 E. Palatine Rd., Prospect Heights, Illinois 60070.

Hamtronics® catalog

Hamtronics® Inc., announces publication of a new expanded June, 1981, catalog, full of goodies for the VHF/UHF/OSCAR enthusiast and two-way radio shops.

The 40-page, two-color catalog features a new five-channel, ten-watt VHF/fm transceiver, new COR and CWID modules for repeater builders, and new accessories, such as rf-tight enclosures for repeaters and power supplies. Also featured are the new T51 (VHF) and T451 (UHF) fm exciter modules. Many new ranges of transmitting and receiving converters have been added, as well as a series of receiving converters to extend the frequency coverage of scanners to new

military, satellite, and commercial bands. The catalog also includes the full line of Cushcraft and Larsen VHF and UHF antennas.

For your free copy, call 716-392-9430 or write to Hamtronics® Inc., 65F Moul Rd., Hilton, New York 14468. (For overseas mailing, please send $2.00 or five IRCs.)

keyer chip

Not all Morse operators realize there are two basic types of iambic operation used in modern electronic keyers. Type "A," offered by the standard Curtis 8044, does not produce a following alternate element when a squeeze is released during an element (an element is a dot or dash). Type "B," employed by manufacturers such as Ten-Tec, Nye, Heath, the Accu-keyer, and others, does produce a following alternate element after squeeze release.

Curtis Electro Devices has designed a new IC called the 8044B (8044BM if the speedmeter function is included). Priced the same as the standard 8044 (and 8044M), the new chip is pin-for-pin compatible and can be used in any existing 8044 socket (or 8043 socket with slight modification). The 8044B is priced at $14.95 in single piece quantities, the 8044BM at $19.95; both are FOB factory and available from stock.

For further information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040.

DS2050 KSR terminal

The DS2050 KSR is a compact and low cost communications terminal for transmission and reception of Baudot, ASCII, and Morse codes (Morse receive optional). The functions of both an electronic data terminal and a high quality RTTY demodulator are combined in one compact cabinet. The DS2050 needs only the addition of a video monitor, Amateur transceiver, and antenna system to form a complete all-mode Amateur station. The received signals are displayed on the video screen in a 24-line by 72-

character-per-line format. Like its predecessor the DS2000, this terminal provides a top line status indication of selected operating modes and code and the exclusive HAL bright-dim display of received or transmitted text (bright for received, dim for transmitted). The terminal operates in word mode while transmitting so that typing errors (or misspelled words) may be edited at the keyboard before they are transmitted. A 255-character hidden transmit buffer allows pretyping of text to be transmitted even while receiving. Other features such as unshift-on-space (USOS) for Baudot reception, keyboard operated switch (KOS) for automatic transmit-receive control, synchronous idle (IDLE or "diddle"), and QBF and RY text messages are included in the DS2050. The DS2050 will operate at 45, 50, 57, 74, and 100 baud with the Baudot RTTY code; 110 or 300 baud with the ASCII RTTY/computer code, and 1-100 WPM Morse Code.

For more information, contact HAL Communications Corp., Box 365, Urbana, Illinois 61801.

antenna tuner

ICOM announces the new IC-AT500 and AT-100 Automatic Antenna Tuner. The Model IC-AT500 handles 500 watts; the IC-AT100 handles 100 watts.

A newly developed detector circuit detects resistance and reactance of the load, and controls powerful motors to automatically tune the two variable capacitors, thus making the tune-up time very short — usually less than three seconds. When the IC-720A or IC-730 (with the optional LDA unit installed) is used, band switching of the tuner can be controlled by the band switch of the IC-720/720A or IC-730. This tuner has dual accessory sockets, so the auto band switching function can be used with the IC-2KL linear amplifier at the same time. The matching circuit can be used for each band, so you are able to make quicky QSYs and enjoy trouble-free operation.

This tuner has four coaxial sockets for antennas, and selects the suitable antenna for each band automatically. When the power of this tuner is turned off, this tuner can be used as an automatic antenna selector. The IC-AT500/AT100 matches ICOM styling for base stations, and is very similar in size and appearance to the IC-2KL. This tuner can be used with 13.8 volts dc or 117 (or 230) volts ac.

The IC-AT100 price is $349.00, and the IC-AT500 price is $449.00. For more information contact ICOM, 2112 116th Ave. N.E., Bellevue, Washington 98004.

short circuits

satellite circuit

The program that appears in the article "Locating Geostationary Satellites" in the October, 1981, issue contains two errors. At the bottom of the second column, the key command STO should be moved down one place so that is to the left of 04. Also, in the same column, code 05 (second from the top) should read 65. Note that in the table on page 68 the satellites from Meteosat down should be listed in degrees west longitude.

Kenscan 74

Please note that, in the Kenscan 74 article that appeared in the January, 1981 issue, pin 16 of U3 was mislabeled pin 6, and pins 3 and 6 of U13 were reversed in the schematic.

memory keyer

The schematic and PC layout of the deluxe memory keyer (**figs. 2** and **6**) in the April issue should show the three display-driver counter ICs (U5D, U6D, and U7D) as 7490s, *not* 7493s.

2-meter synthesizer

An error appeared in the printed-circuit layout for the 2-meter synthesizer designed by K9LHA (December, 1979, page 14). The bottom part of **fig.** 7 shows jumpers J1 and J2 connected to pin 12 of U6 (74197); these two jumpers should go to pin 13. The schematic of **fig. 5** is correct.

FEBRUARY 1982 / $2.50

ham radio magazine

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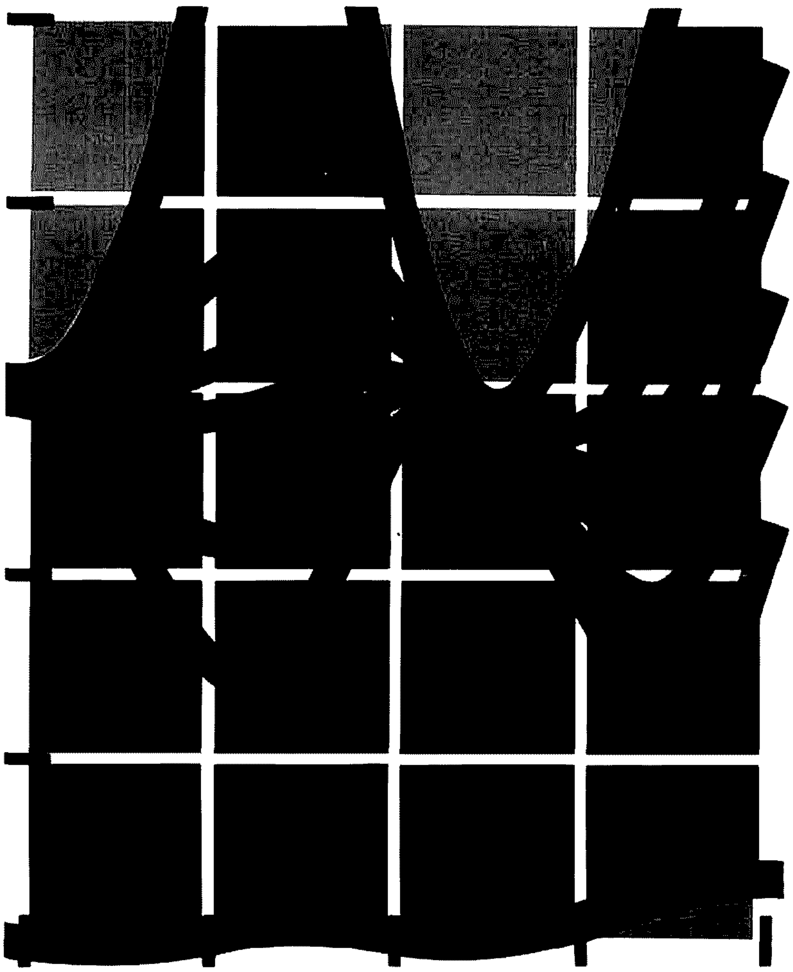
focus on communications technology



matching networks

ham radio

magazine

FEBRUARY 1982

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Observation & Opinion

This month we present a guest editorial by *ham radio* staff member and assistant publisher J. Craig Clark, N1ACH, who has some comments regarding the condition of the 160-meter band. Alf Wilson, W6NIF, **editor**.

I am more than a little concerned about something that happened recently on 160 meters. It was unnecessary and violated my idea of how one should solve a problem. It also was a display of the sorry state of sportsmanship now more than ever commonplace in Amateur Radio.

What am I talking about? On the weekend of December 4-6, 1981, the annual ARRL 160-meter DX contest was held. This was the first contest run under the ARRL's new voluntary 160-meter band plan, which partitions the band into distinct CW and SSB segments. An East Coast Amateur who was upset with the band plan had set up shop right in the middle of the DX window and was soliciting names for a petition to protest the new plan. He was on frequency for quite a while and kept many hams from working any DX until he went away.

Now let me state that I, too, dislike the band plan. Band plans are great where they are needed. I think that band plans can be of tremendous help on the VHF/UHF bands for accommodating repeaters, weak signal, EME, and other special forms of communications.

On the other hand, the 160-meter band has been called the "gentlemen's band." For more years than I have been a ham, 160 has survived partitioning for LORAN A, low power, poor propagation, and other maladies besides. Both modes of transmission, CW and Phone are used, and only occasionally has an argument erupted. With only 50 kHz of space the band was sometimes very cramped, but always cooperation and peaceful coexistence prevailed. By convention, CW stations congregate in the bottom 10-15 kHz of the band and move higher only when things get crowded. The sidebanders (and a-m'ers, who also, by the way, have every right to be on the air) set up shop above 1.815 MHz. Peaceful and cooperative.

Now, with the elimination of all restrictions below 1.9 MHz, the problems of limited space should be behind us. And until this weekend, things seemed to be OK. But they are not.

Now this East Coast ham who was getting callsigns for his petition went about his project in the wrong way. Instead of interfering during a contest (remember, I don't like the plan either), why not get names over a period of several nights or weeks during casual operating? That, to me, is a far less obnoxious way to go about putting together a protest petition, and one that might get more supporters. By interfering with the contest he may have made more enemies than friends.

If you don't like something, write the ARRL President, W2HD, local ARRL officials, directors, or the author of the band plan, Dave Sumner, K1ZZ. Make them realize that the whole world does not endorse the ARRL plan. Maybe then we can get them to revoke or rethink their plan. Is it really necessary to have more regulations, or could we make do without the plan?

I just wonder — did the directors ever see the comments about the band plan that were sent in? If one looks at the *QST* correspondence column, one would think the whole world went along with the plan. I would be surprised to learn that I'm the only Amateur who was unhappy about the band plan. Last night there were at least five SSB QSOs in progress below 1.825 MHz. Either they never heard of the plan or they also don't agree with what has been adopted.

In this day and age of deregulation, why not let the 160-meter band be an example of how peaceful coexistence can work? It already has worked for many years. Is there reason to expect that it can't now? I don't think so. I don't buy the arguments about technical limitations or whatever as being sound reasons for a band plan. I am afraid it is needless regulation and I would rather see no plan than this one.

I support action to revoke the ARRL band plan. But I will not ruin the pleasure and operating enjoyment of others to show my sentiments. I am afraid that this controversy may turn 160 meters from a "gentlemen's band" into a mess the likes of 20 meters. Is that what we want? I don't think so. For those who don't like the band plan, let's not ruin one band where we all can have fun. Let's all observe the DX window — it was there long before the band plan. And let's make sure ARRL officials know of our feelings. Begrudgingly, I will abide by the band plan. I will, however, continue to urge the ARRL President and directors to reconsider it.

J. Craig Clark, N1ACH, assistant publisher

comments

9.3 MHz anyone?

Dear HR:

I have several comments pertinent to Gary O'Neil's fine article on antenna traps.[1] Although I appreciate his referencing an article of mine,[2] I must point out that "my" method of trap construction is not original with me. I can recall seeing more than one mention of the use of coax as a capacitor prior to my application, which was stimulated by a clever technique developed by Mathison.[3]

It is very important to realize that there is no such thing as "1.25-inch pipe"! There is 1¼-inch pipe, which actually is 1.66 inches in diameter, and there is 1.25-inch tubing, which actually is 1.25 inches in diameter. *ham radio*'s policy of printing all non-integral quantities as decimals is very confusing in this case: author O'Neil means *1¼-inch pipe* (1.66-inch diameter), but *ham radio* printed "1.25-inch PVC stock" on page 14. There's a big difference, as I found out when I constructed 40-meter O'Neil traps on 1.25-inch-diameter forms: Anybody need a set of 9.3 MHz traps?

In a similar vein, it also is important to note that *any* length of wire connected to a tuned circuit such as an antenna trap will cause its resonant frequency, when measured on the bench with a dip meter, to appear to be lower than it actually is. The 3-inch connecting leads specified on page 14 will cause the resonant frequency of a 7-MHz trap, as measured with a dip meter, to appear to be 30 to 45 kHz lower than the true value. This may be verified by connecting leads of differing lengths, measuring the apparent resonant frequency each time, plotting these frequencies as a function of lead length, and finally extrapolating backwards to zero lead length. This characteristic in no way affects the value or utility of O'Neil's method, but it is a potential source of trouble for those attempting to build and tune traps.

I have always understood that PVC is a poor choice as a coil form because of its high rf loss.[4] I have no feel for how serious this might be in the present application, but comments from those who are knowledgeable would be useful. If PVC truly is a very lossy material in the high-frequency region, it probably should not be used in antenna traps.

Finally, it is interesting to compare O'Neil's coax-cable trap design to that of Johns.[5] It might be useful to perform a quantitative comparative study of the two designs.

Gary O'Neil is to be complimented on his thoroughness and ingenuity in this project. The resulting article is interesting, useful, and well written.

references

1. Gary E. O'Neil, "Trapping the Mysteries of Trapped Antennas," *ham radio*, October, 1981, page 10.
2. Gary E. Myers, "A Two-Band Half Sloper Antenna," *QST*, June, 1980, page 32.
3. J.R. Mathison, "Inexpensive Traps for Wire Antennas," *QST*, February, 1977, page 18.
4. W1CKK, "A Dielectric No-No," Hints & Kinks for the Radio Amateur, 1978 Edition, ARRL, page 68.
5. Robert H. Johns, "Coaxial Cable Antenna Traps," *QST*, May, 1981, page 15.

Gary E. Myers, K9CZB
Naperville, Illinois

satellite locator

Dear HR:

The satellite locator program for the TI59 by Mr. Walter Pfiester, W2TQK, (October, *ham radio*) works OK for azimuth but needs the following change or addition to run for elevation.

In program step 25 (STO, 03, R/S), insert (between R/S and RCL, 05. It then looks like this: STO, 03, R/S, (, RCL, 05.

I made one other change at program steps 21, 22, and 23. Change them to INV, TAN, +, *RCL, 10,* =, STO, 03. This way I can enter 180 or 360 as required at register 10 when I key in the other data. A *very good job*, Walt.

Frank Sheehan, W1DHX
Port Isabel, Texas

line losses

Dear HR:

With respect to the recent letters by WD4KMP and WB9TQG in the September, 1981, issue, I don't think it is so difficult to demonstrate that line losses are higher when the line has a high SWR. This is not a mathematical proof, but rather a heuristic, common-sense type.

If a line has a high SWR, it has, by definition, peaks and valleys of voltage and current on it. Since the power lost in the line is divided into two major parts, the loss in the dielectric and in the copper, and since one varies with the square of the voltage while the other varies with the square of the current, it follows naturally that the peaks of voltage and current increase the line losses. It is true that the valleys decrease the losses, but since the power losses vary as the square of the voltage and current, the added losses more than make up for the reduced losses at the valleys. In other words, the least possible loss is in a line that is "flat," where there are no high peaks of voltage or current.

The net result of this is that I agree with WB9TQG and the various references he quotes on line losses.

James N. Thurston, W4PPB
Clemson, South Carolina

upgrade

Dear HR:

I do appreciate Robert Shrader's articles on upgrading. Please keep them coming. Many of us need this approach to make us more proficient.

Lloyd Morse, WA7YJF
Allyn, Washington

presstop

SIX RUSSIAN SATELLITES, RS3 through RS8, were launched on December 17 and are now in a nearly circular orbit around the earth at an average altitude of nearly 1700 km. The six are steadily moving away from each other with slightly differing orbits, and by December 28 their equatorial crossing times were spread over more than an hour and crossing points nearly 20 degrees.

All Six Have Been Transmitting telemetry data, with each series preceded by the spacecraft's call (e.g., "RS3"). RS3, 5, and 7 all have "robot transponders," and at least one has been worked by a number of stations around the world. Robot availability is indicated by a "CQ," stopping when a signal appears in its input passband. Sending (for example) "RS5 de W9XXX AR" should bring the response "W9XXX de RS5 QSO NR xxx". It may also respond "QRZ," "QRM," or "RPT" if it misses a call, or "QRQ" or "QRS" to calls made below or above its 10-25 WPM acceptance range.

Beacon Frequencies for the even numbered birds are: RS4, 29360/29403; RS6, 29411/29453; and RS8, 29461/29502. Their 40-kHz-wide OSCAR-style transponders have apparently not been activated as of this writing. One indication of transponder status in any of the six is the first, or "K," group telemetry number, which indicates power output. A reading of anything other than "KØØ" should mean the transponder is on.

Interference To The RS Satellites from terrestrial stations is becoming a real problem, with their covering so much of the 29.3-29.5 MHz spectrum. SSB, AM, and FM signals have all been heard in recent weeks on top of or breaking over onto the new satellites. Non-satellite users should try to stay below 29.3 or above 29.5 to avoid the problem.

10 MHZ WAS STILL WELL OFF in the future, so far as U.S. Amateurs are concerned, despite some last-minute efforts by the League and others to push some kind of temporary authorization through by January 1. Though the idea of making the band available for U.S. Amateurs by the January 1st date that was made possible by WARC '79 did have support from several key parts of the Commission, some questions about details prevented complete acceptance. Another difficulty was opposition among current U.S. users of the 10.10-10.150 MHz segment, both common carrier and government. As a result, barring a drastic change in the situation as it exists at press time, it's unlikely that the band will be opened to U.S. Amateurs until all treaty and rule making procedures are accomplished.

Considerable 10-MHz Activity was expected from other parts of the world on January 1, however. West Germany, Switzerland, and Australia are among the major nations joining the British Isles on the band, and at least one Scandinavian country and some smaller nations were expected on as well.

The "CW Only" Concept for the new band seems to be meeting some resistance in IARU Region 3. With the exception of Japan, the Amateur population of the Far East is quite sparse. As a result, Amateurs there (and possibly some government officials) are pushing for some sort of phone sub-band. How that could be accomplished in a 50-kHz wide band is another question.

JAPANESE REPEATERS ARE EXPECTED to be authorized in the near future, and the JARL has announced new VHF/UHF bandplans set up to accommodate them. Key points of the new bandplans are enlarging of the FM segments of the 144 and 440 MHz bands to provide room for repeaters, and moving the present 52.5-MHz beacon frequency to 50.010 MHz. The latter move puts Japan into agreement with the rest of the world, with beacons at the lower band edge to better signal band openings.

RFI CONTROL WON'T BE A PART of K7UGA's pro-Amateur Radio bill as it's shaping up in the House of Representatives. The House version of S.929, termed "Track 1" by subcommittee chairman Timothy Wirth, has deleted both the controversial anti-RFI and CB delicensing provisions. The RFI aspects were strongly opposed by the Electronic Industries Association, while many CB user groups are fighting the delicensing idea. Both items are to be considered later, however, as "Tracks 2 and 3."

FCC Participation In Conventions and similar activities is encouraged by a new provision to the bill added by the House. It would permit the FCC to accept compensation for its attendance at such events, so FCC-administered exams and seminars at hamfests would no longer have to be financed from the commission's budget.

Passage Of This Far-Reaching legislation could take place fairly soon if the Senate concurs with the changes that were incorporated by the House.

EXPANSION OF U.S. PHONE BANDS, 220-MHz phone privileges for Novices, and proposals to change some power limits are all likely to be seeing FCC action in the near future. The phone band expansion, despite opposition from outside the country, will probably come up first. The power limit proposals, one to reduce CW power and the other to permit higher power levels for moonbounce work, are likely to be tied in with long-standing FCC attempts to develop new power-specifying techniques.

BILL SCARBOROUGH, N1BXG, HAM RADIO graphic production manager, has been promoted to assistant advertising manager in addition to his previous responsibilities.

response of

pi, pi-L
and
tandem quarter-wave-line

matching networks

Bandwidth considerations using the HP-34C to solve network equations

It is usually assumed — but not shown — that the response of pi and pi-L impedance-matching networks used in exciters and linear amplifiers resembles that of ordinary parallel-resonant LC circuits. The reason is that considerable computation is involved to generate the response curves. With the availability of relatively low-cost programmable calculators such as the HP-34C the problem becomes much simpler. This article presents the response characteristics of several commonly used pi and pi-L networks, developed with the aid of an HP-34C program and the SOLVE capability of this machine for finding specific maxima, minima, and points on the curves. The last part shows the response for some broadband matching systems using tandem transmission lines, each a quarter-wavelength long at the design (center) frequency.

The networks selected are tabulated in **table 1**, which gives the reactance values in ohms for five different input resistances at resonance (matched conditions) and for two different Q values. The relationships used were programmed into the HP-34C; the programs will be found in *The Match Book*, a manuscript now awaiting publication.* The design equations were given in an *article* by the author some years ago.[1]

The pi-L network assumes the same transformation ratio for the pi and for the output L, as is customary; that is, the input pi matches to the geometric mean ($\sqrt{R_{in} \times 50}$ ohms in this case) between the end resistances, and the L takes it the rest of the way between this intermediate resistance and 50 ohms. Only networks with shunt capacitance and series inductance are considered here, because they have the best harmonic attenuation and are the most com-

*Programs for pi and pi-L networks are available from *ham radio* upon receipt of a self-addressed stamped envelope.

By **R.W. Johnson, W6MUR,** 2820 Grant Street, Concord, California 94520

monly used. The output capacitance of the pi is then combined with the input capacitance of the L to result in a four-reactance network as shown in **table 1**.

network parameters

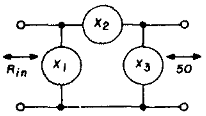
Use of the polar-to-rectangular (and vice versa) capabilities of the HP-34C, and its ability to handle subroutines makes it feasible to construct a fairly simple program for finding the input impedance and all of its components: resistance, reactance, impedance and phase angle. **Fig. 1** shows the input impedance of the pi ($Q = 10$) matching 3000 ohms to 50 ohms, and defines the various critical maxima and frequencies:

R_m	maximum resistive component
X_{m1}	maximum positive reactance component
X_{m2}	maximum negative reactance component
$\|Z_m\|$	maximum magnitude of input impedance
ρ_1	frequency for X_{m1}
ρ_2	frequency for X_{m2}
ρ_3	frequency for R_m
ρ_4, ρ_5	frequencies for $0.707R_m$
ρ_6	frequency for $\|Z_m\|$
ρ_7, ρ_8	frequencies for $0.707\|Z_m\|$

table 1. Matching networks studied (all match to 50 ohms).

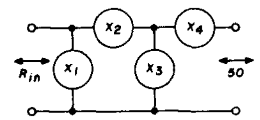
pi network values (ohms)

Q	R_{in}	X_1	X_2	X_3
8	3000	−375.00	382.5542	−173.2051
8	2750	−343.75	356.5016	−117.2604
8	2500	−312.50	328.7586	− 91.2871
8	2250	−281.25	300.0000	− 75.0000
8	2000	−250.00	270.4791	− 63.2456
10	3000	−300.00	321.5834	− 60.4858
10	2750	−275.00	297.1778	− 54.6729
10	2500	−250.00	272.5235	− 49.5074
10	2250	−225.00	247.6236	− 44.8211
10	2000	−200.00	222.4734	− 40.4888



pi-L network values (ohms)

Q	R_{in}	X_1	X_2	X_3	X_4
8	3000	−375.00	494.7104	− 72.8549	129.8650
8	2750	−343.75	456.3520	− 69.7073	126.6511
8	2500	−312.50	417.7783	− 66.3802	123.1977
8	2250	−281.25	378.9629	− 62.8462	119.4592
8	2000	−250.00	339.8733	− 59.0706	115.3750
10	3000	−300.00	400.0911	− 63.8365	129.8650
10	2750	−275.00	368.9983	− 60.9351	126.6511
10	2500	−250.00	337.7391	− 57.8778	123.1977
10	2250	−225.00	306.2931	− 54.6418	119.4592
10	2000	−200.00	274.6345	− 51.1982	115.3750



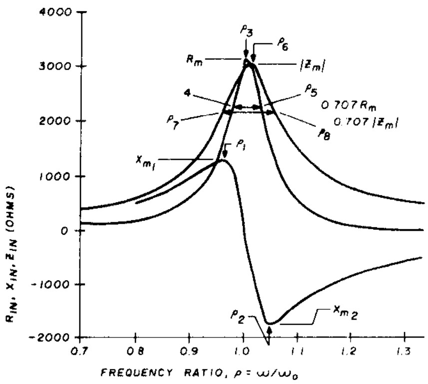


fig. 1. Input impedance of a pi network for matching 3000 to 50 ohms; $Q = 10$.

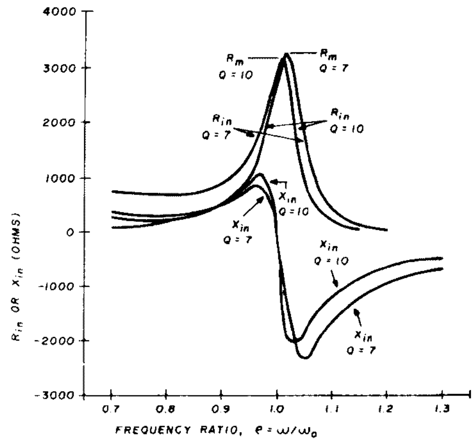


fig. 2. Pi-L network response for matching 3000 to 50 ohms, $Q = 7$ and $Q = 10$.

Table 2 is a tabulation of each of these critical parameters for twenty different networks, covering five different input (design) resistances and two design Q values for each of the pi and pi-L. The maxima were discovered using the SOLVE program in the HP-34C, which requires a progressively refined estimate of what the maximum is so it can be subtracted from the value found by the calculator. This iteration takes several minutes to run for each data point. Since the frequency differences are small, frequency is carried out to six decimal places.

comparison of pi and pi-L response

Fig. 2 is the input impedance response of the pi-L (3000-ohm design) for two different Q values. In this

table 2. Critical frequencies and peak values for typical pi and pi-L matching networks of table 1.

Q	R_{in}	ρ_1	ρ_2	X_{M1}	X_{M2}	ρ_3	R_M	ρ_4	ρ_5	ρ_6	$\|Z_M\|$	ρ_7	ρ_8
						pi network							
8	3000	.93962	1.06433	1299.530	−1702.240	1.004202	3013.515	.963027	1.043497	1.008310	3026.807	.947860	1.072485
8	2750	.93994	1.06399	1177.944	−1575.121	1.004500	2764.344	.963411	1.043451	1.008890	2778.427	.948784	1.072657
8	2500	.94041	1.06352	1058.528	−1445.347	1.004785	2514.969	.963883	1.043306	1.009439	2529.633	.949836	1.072652
8	2250	.94102	1.06292	941.432	−1312.838	1.004500	2265.148	.964434	1.043070	1.009954	2280.321	.951006	1.072473
8	2000	.94184	1.06214	826.759	−1177.570	1.005306	2015.392	.965085	1.042721	1.010426	2030.391	.952296	1.072109
10	3000	.95292	1.04961	1288.648	−1715.496	1.003452	3015.191	.971367	1.033700	1.006824	3030.148	.959790	1.056201
10	2750	.95314	1.04922	1174.164	−1579.818	1.003550	2764.967	.971681	1.033508	1.007011	2779.655	.960394	1.055977
10	2500	.95380	1.04879	1060.995	−1442.766	1.003641	2514.579	.972027	1.033279	1.007185	2528.870	.961041	1.055690
10	2250	.95430	1.04830	949.126	−1304.353	1.003725	2264.024	.972410	1.033007	1.007342	2277.750	.961735	1.055300
10	2000	.95495	1.04774	838.573	−1164.591	1.003800	2013.290	.962836	1.032685	1.007480	2026.777	.962487	1.054884
						pi-L network							
8	3000	.964044	1.043542	885.242	−2153.591	1.008705	3134.395	.980340	1.032437	1.026992	3132.000	.976305	1.060246
8	2750	.964018	1.043432	819.624	−1965.628	1.008562	2869.704	.980291	1.032294	1.016151	2974.000	.978728	1.056761
8	2500	.963500	1.043313	752.888	−1778.753	1.008409	2605.498	.980244	1.032137	1.015433	2698.014	.978530	1.056499
8	2250	.963500	1.043175	685.114	−1593.042	1.008245	2371.818	.980199	1.031963	1.015174	2422.701	.978319	1.056213
8	2000	.963500	1.043016	616.160	−1408.571	1.008072	2078.692	.980158	1.031767	1.014889	2143.336	.978100	1.055887
10	3000	.969708	1.034716	1020.733	−2001.451	1.005421	3080.231	.982849	1.025118	1.010236	3153.783	.979644	1.043867
10	2750	.969733	1.034634	941.466	−1828.769	1.005338	2821.651	.982838	1.025019	1.010930	2887.493	.979544	1.043685
10	2500	.969767	1.034536	861.456	−1656.840	1.005250	2563.337	.982831	1.024909	1.009944	2621.684	.979443	1.043482
10	2250	.969814	1.034500	780.659	−1485.705	1.005155	2305.296	.982829	1.024785	1.009780	2356.375	.979341	1.043259
10	2000	.969800	1.034292	699.026	−1315.429	1.005051	2047.700	.982836	1.024642	1.009602	2091.599	.979240	1.042995

case, the impedance curve, $(|Z|)$, was omitted to avoid cluttering the curves.

Comparison of **fig. 2** with **fig. 1** shows several interesting things. First, although the reactance peaks below and above resonance are not equal in either case, the difference is more marked for the pi-L, for the same design Q. Second, the effective Q of the network, which may be taken as the reciprocal of the difference between ρ_5 and ρ_4 or, if you prefer, between ρ_8 and ρ_7, is considerably higher for the same design Q in the pi-L than for the pi. One would expect this, of course, since there are in effect two additional reactances in the pi-L, and it is well known that the harmonic attenuation is much greater with the pi-L than the pi. However, the same effective Q as for the pi can be obtained at a lower design Q for the pi-L. Instead of using $Q = 10$ as is customary, $Q = 8$ or even $Q = 7$ can be used for the pi-L, and thus save something on the size of the high-voltage input capacitor at the lower frequencies. This is, however, at the expense of more inductance and hence larger coils.

pi-L input impedance near resonance

It is also interesting to examine the input impedance over a very narrow band in the vicinity of resonance. **Fig. 3** is a plot of the *change* in input resistance versus 3000 ohms, and of the total reactance, for the $Q = 10$, 3000/50 ohm pi-L. Shown on the figure is the voice bandwidth for 3.8 kHz at 3.8 MHz, on the assumption that the band is centered at the design frequency where there is zero reactance. It can be seen that there is a total change of about 56 ohms (out of 3000 ohms) over the band due to the fact that R_{in} peaks (in this case) about 20.6 kHz higher than the design frequency. This approximate 2 percent change in resistance presented to the final amplifier tube over the voice bandwidth no doubt contributes something to distortion, although it is probably *negligible. In any event, using a lower* design Q will certainly correct whatever problem may exist.

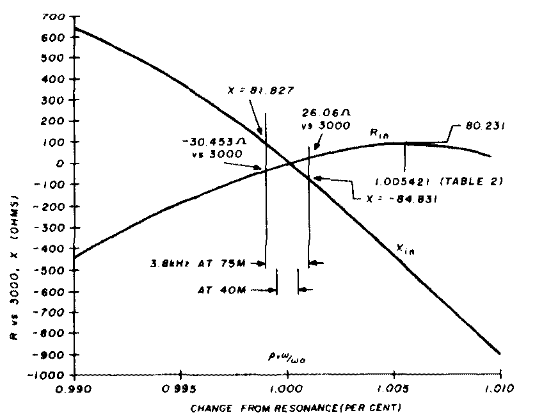


fig. 3. Change in input resistance versus 3000 ohms R_{in} for a Pi-L network over a 3.8-kHz voice bandwidth; $Q = 10$.

Finally, keep in mind that these curves assume a *constant* 50-ohm resistive load on the output. A reactive load with high VSWR will cause the networks to behave quite differently.

While there are no earth-shaking conclusions from all of this, it is nice to know for sure that the input impedance of pi and pi-L networks is indeed very similar to that for parallel-resonant circuits, and the results certainly illustrate very well the powerful capabilities of the HP-34C programmable calculator.

tandem quarter-wave lines

Tandem quarter-wave matching sections, with different Z_0s for each section, tend to exhibit broader bandwidth matching characteristics than most other types. Again, the HP-34C programmable calculator is of enormous value to study some typical cases. The input impedance of a section of transmission line θ degrees long terminated in a complex series impedance $\alpha + j\beta$, with the Z_0 of the line being K times the Z_0 of the previous section is given by

$$Z = K^n Z_0 \left[\frac{\dfrac{Z_L}{K^n Z_0} + jT}{1 + jT \dfrac{Z_L}{K^n Z_0}} \right]$$

$$= K^n Z_0 \left[\frac{\dfrac{\alpha}{K^n Z_0} + j\left(T + \dfrac{\beta}{K^n Z_0}\right)}{\left(1 - \dfrac{\beta T}{K^n Z_0}\right) + j\left(\dfrac{\alpha T}{K^n Z_0}\right)} \right], \; T = \tan\theta \qquad (1)$$

Introducing the variables $v = \dfrac{K^n Z_0}{\alpha}$ and $w = \beta/\alpha$, **eq. 1** can be rewritten into a form more suitable for calculator use as

$$Z = K^n Z_0 \frac{1 + j(Tv + w)}{(v - wT) + jT} \qquad (2)$$

Expressing this in the series form $\alpha + j\beta$, this is then the load for the next section of line for which the Z_0 is $(K)^{n+1} Z_0$. The HP-34C contains a built-in incrementing program, using the I register, for either increasing or decreasing n. Thus the program is developed starting with $n = 0$ ($K^0 = 1$), computing the input impedance of this section for which $\beta = 0$ and $\alpha = R$. The resulting values of α and β are stored,

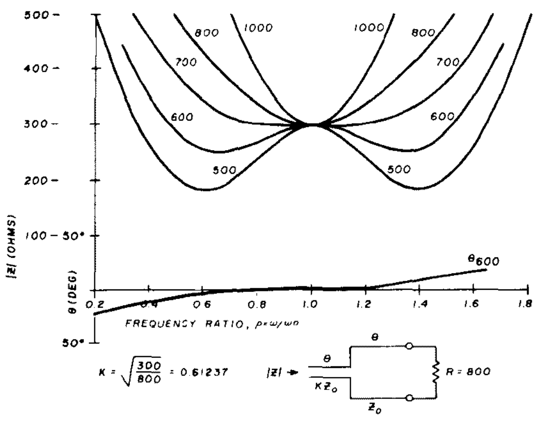


fig. 4. Input impedance of two tandem quarter-wavelength lines for matching 800 to 300 ohms.

then used in the next cycle for which $n = 1$, and so on for however many sections are assumed.

bandwidth considerations

Using this program, several interesting tandem-quarter-wave line cases were examined. **Fig. 4** shows the input impedance of a two-section line for matching 800 to 300 ohms, for five different Z_0 values. There is an "optimum" value of Z_0, in this case around 600 ohms, which will produce the broadest bandwidth. The input phase angle is shown in **fig. 4** for this "optimum" value of Z_0. The practical manifestation of this case would be the first line (connected to the 800-ohm load) to have $Z_0 = 600$ *ohms*, and the second line would have a Z_0 of 367 ohms. The bandwidth would be from 0.38 to 1.62 for VSWR 1.2:1 or less, or a frequency ratio of 4.26:1.

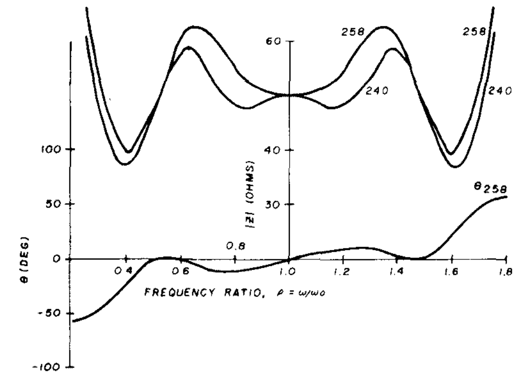


fig. 5. Response of a four-section tandem line, matching 300 to 50 ohms. Each line is nominally one-quarter wavelength long at $\rho = 1$ for $Z_0 = 240$ *and* 258 *ohms*.

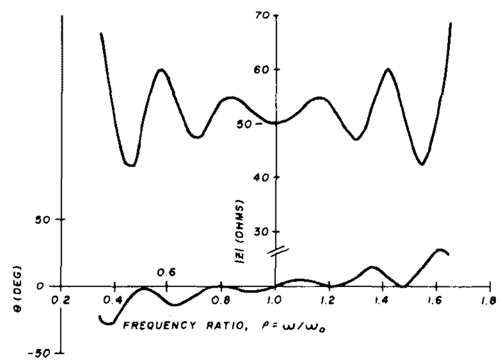


fig. 6. Eight-section quarter-wavelength line showing response for matching 800 to 50 ohms; $Z_0 = 700$ *ohms*.

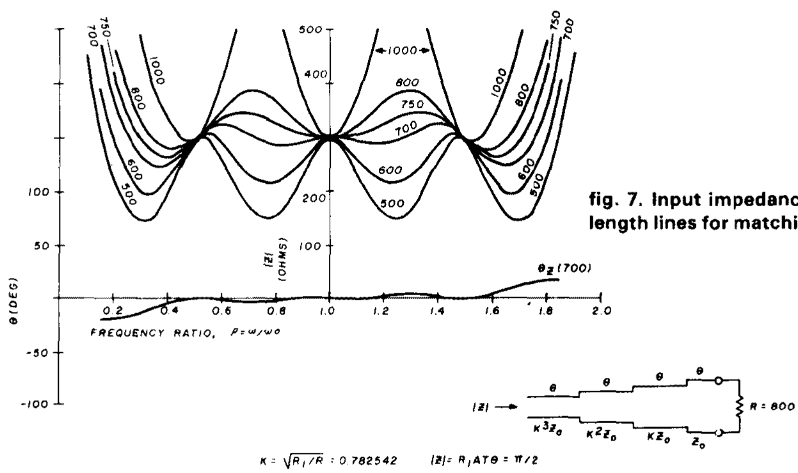


fig. 7. Input impedance of four tandem quarter-wavelength lines for matching 800 to 300 ohms.

As with any matching system, when the transformation ratio increases, the bandwidth decreases. So for a 300:50 ohm case two sections are not enough for a really broad bandwidth. Fig. 5 shows the results for a four-section line, where the "optimum" Z_0 is now about 258 ohms. Here, the input impedance is within 1.25:1 of 50 ohms from frequency 0.31 to 1.74, a frequency ratio of 5.61:1. The Z_0s would be 258, 165, 105, and 67 ohms for the four sections. The total line length would, of course, be a full wavelength at the center frequency.

Fig. 6 shows the 800:50 ohm case, this time with a still higher transformation ratio. Here, eight sections are necessary, and the optimum Z_0 is about 700 ohms. It can be seen that the bandwidth extends from 0.37 to 1.63, or over a 4.4:1 frequency band within VSWR 1.2:1. Here, the Z_0s would be 700, 495, 350, 247.5, 175, 124, 87.5, and 62 ohms for the eight sections.

Finally, for the 800:300 ohm case, which had a bandwidth of 4.26:1 in a two-section configuration, ρ can be pushed to 0.2 versus 1.8, or *9:1 in frequency* by going to a four-section line. This is shown in fig. 7, in which several Z_0 values have been included so that the reader can see what happens to the various peaks and valleys as Z_0 is changed. The "optimum" case is at $Z_0 = 700$ ohms, the lines being 700, 548, 429, and 335 ohms Z_0 respectively. The phase angle of the input impedance is shown for this optimum Z_0.

Eventually, of course, as one goes to a very large number of sections and a very gradual taper on Z_0, one approaches the tapered transmission line, or exponential line, which has been around for many years as a broadband matching system. Such lines are, however, hard to build and require some large spacings at one end and impracticably small spacings at the other, and may be several wavelengths long. The tandem quarter-wave sections are shorter, more practicable to build, and nearly as good on bandwidth.

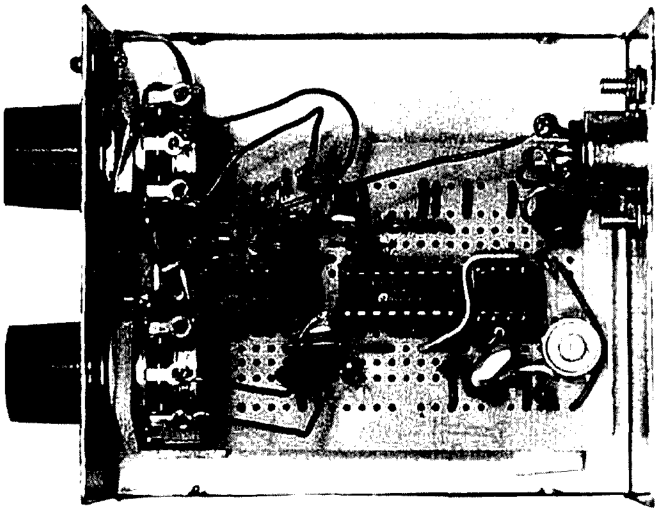
summary

This article has attempted to shed some light on bandwidth considerations in pi, pi-L and tandem-line matching systems. Intractable analytically, these various configurations are easily studied with the aid of the enormous computing power of the HP-34C as a relatively inexpensive machine. More information on these and related subjects will be found in *The Match Book*, which some astute publisher will probably produce within a year.

reference

1. R.W. Johnson, "Pi Network Nomograph," *Electronics*, September 12, 1958, page 108.

ham radio



blanking the Woodpecker

part two: a practical circuit

In part one, I discussed a number of aspects of the Woodpecker transmissions which might allow one to go about blanking them. These are, briefly:

1. Repetitive pulses of relatively long duration.
2. Broad bandwidth — typically 50 kHz.
3. Likelihood of occurrence throughout the high-frequency band.
4. Very precise pulse repetition frequency — usually 10 Hz.

Most existing Amateur transceiver noise blankers are designed to deal with intense, short-duration noise spikes of the type generated by car ignitions. These are typically 0.5 millisecond or less in duration. The Woodpecker pulses, on the other hand, are usually 10 to 20 milliseconds long, and consist of a number of spikes of varying amplitude. Because the Woodpecker pulses are quite different from ignition noise, many Amateur transceiver noise blankers do not perform effectively on the pulses, taking only 2 or 3 S-points off. When the Woodpecker is at strength S9 + 20, this is not much help. Some of the newer transceivers (such as the ICOM 720A) are reportedly more effective, but the majority of transceivers in operation today are wiped out by the Woodpecker when it is really strong.

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As discussed in the first article, conventional noise blankers operate by amplifying noise pulses, and use the result to blank a noise gate early in the i-f chain. This works well if the noise pulse is strong enough to allow the noise amplifier to create a blanking control pulse. However, many of the component spikes in a Woodpecker pulse are not intense enough to trigger the blanking, so a lot of the pulse gets through.

An alternative approach was outlined in my previous article, which has been found to be quite effective against the Woodpecker. This approach makes use of the fact that the Woodpecker pulse repetition frequency (PRF) is precisely defined. About 90 percent of the time it is 10 Hz, to an accuracy of one part in 100,000 or better. Other equally precise PRFs are used, particularly 16 Hz, for the remaining 10 percent or so of the time. This precision in the Woodpecker PRF has led to the idea of a synchronous noise blanker, where a crystal-locked 10-Hz signal is generated locally, synchronized with the Woodpecker, and used to control a blanking gate in the usual way.

In this article, a circuit is described that blanks the Woodpecker pulses early in the receiver i-f stages, before they swamp the AGC and before they get

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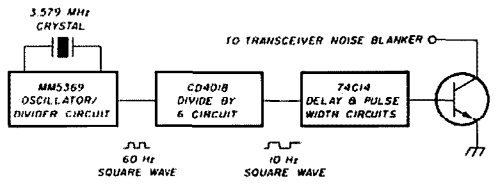
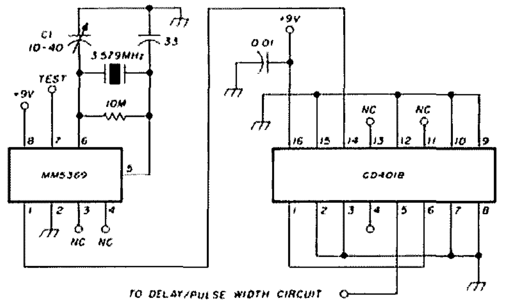


fig. 1. Block diagram of a synchronous noise blanker circuit. (See appendix for notes on devices.)



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 2. Oscillator/divider circuit.

broadened by the narrow selectivity stages. The circuit is designed to be connected into transceiver noise blankers of the type that operate by reverse biasing diodes in a series gate. The circuit should operate without changes on the TS-520, TS-820 and earlier models on the ICOM 701, and any rigs using similar blanker circuits, with minimal modifications to the rig. It has been used to good effect on my ICOM 701 for several months.

how it works

A block diagram of the circuit is shown in **fig. 1**. An MM5369 oscillator/divider integrated circuit, of the type used in many quartz clocks, together with a 3.579-MHz color TV crystal is used to generate an accurate 60-Hz square wave (reference 1). This signal is digitally divided by six by the CD4018 CMOS IC, resulting in a crystal-locked 10-Hz square wave. This 10-Hz signal is processed through a series of inverting CMOS Schmitt triggers (all contained in one 74C14 IC), the details of which are described below. The output of these stages is used to turn a transistor off and on. It is the collector of this transistor that is connected to the transceiver noise blanker, upon which it imposes a 10-Hz blanking pulse. The circuit diagram for the oscillator/divider stage is given in **fig. 2**.

delay and pulse-width circuits

To understand the workings of the 74C14 circuit, which forms the essence of this blanker, it is necessary to delve briefly into the arcane digital world of CMOS. Many Amateurs seem to have a fear of digital circuits and prefer to stick with good old analog tubes and transistors. There is really no good reason for this, as in many ways digital circuits are more predictable than analog ones. For those with no experience in CMOS, the *CMOS Cookbook* by Don Lancaster (reference 2) is a very good introduction. The operation of the 74C14 circuit is described in Chapter 4 of that book, and divide-by-six circuit in Chapter 6.

The easiest way to understand how the 74C14 circuit works is to look at what needs to be done to blank the Woodpecker. As described in the previous article, the object of this circuit is to provide a blanker control signal that is exactly synchronized with the Woodpecker. It should turn off the blanker gate only while the Woodpecker pulse is present, leaving the rest of the time between pulses for the desired signal to come through.

Thus we need a variable delay circuit to allow us to synchronize the blanking with the Woodpecker, and a means of varying the output pulse so that it blanks for no longer than necessary. It turns out that both these functions can be served by the same type of circuit, which Lancaster refers to as the "half monostable."

Consider the circuit in **fig. 3**. If a square wave is fed to the input, and the RC time constant is much shorter than the period of the square wave, the RC circuit differentiates; that is, it gives a positive spike when the input goes up, and a negative spike when the input goes down. As some CMOS circuits don't like negative input voltages, a diode is used to short out the negative spike. If this positive pulse is fed to a Schmitt trigger circuit (CMOS or otherwise) the output will be a narrow positive pulse, in synchronization with the rising edge of the input square wave.

If the RC time constant of the circuit is about the same as the period of the input square wave, however, the output is going to look like a sagged square wave; that is, the dc level does not decay very much

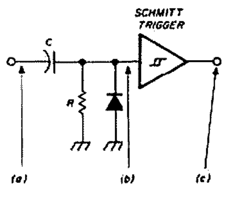


fig. 3. Half-monostable circuit.

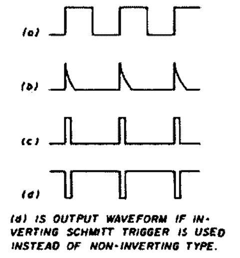


fig. 4. Waveforms for circuit in fig. 3.

before the square wave goes down again. Again, the diode cuts off the negative part of the wave. The waveforms are shown in **fig. 4**.

If this type of decaying square wave is fed to a Schmitt trigger, the output is a much broader pulse whose width is set by the point where the decaying voltage goes below the triggering level. As before, the beginning of the Schmitt output pulse is synchronized with the rising edge of the input square wave. Now if we make the resistor R a potentiometer, the RC time constant can be varied, and thus the width of the output pulse from the Schmitt trigger can be varied. It is most important to understand this, as the whole functioning of the synchronous blanker depends on this operation.

If you look up the specification sheet for the 74C14 in reference 1, you will notice that it contains six separate inverting Schmitt trigger circuits. Two points arise from this. The first is to point out the economy of using CMOS — only one IC is needed — and the second is that the output from an inverting Schmitt trigger is the inverse of an ordinary one. Thus, in a circuit such as **fig. 3**, the output of the inverting Schmitt trigger is positive all the time except for a brief drop to zero volts at the rising edge of the input square wave.

Okay, that should provide enough background to look at how the whole delay/pulse width circuit works. The circuit diagram for the delay and pulse width circuits is given in **fig. 5**.

The first stage in the delay/width circuit is a half-monostable (that is, as in **fig. 3**) using an inverting Schmitt trigger and a very short RC time constant (0.2 millisecond). The output from this stage is a brief negative-going spike synchronized with the rising edge of the input 10-Hz square wave.

The next stage is a half-monostable with a longer, variable RC time constant. The input to this is a square wave with a very high mark-to-space ratio; that is, almost all mark and no space. This waveform decays in the same way as described above, and the output from the inverting Schmitt trigger is a negative-going pulse whose width is variable from nearly zero to 0.1 second. The start of this pulse is also synchronized with the rising edge of the 10-Hz square wave input to stage 1.

Stage 3 is similar to stage 1: a half-monostable with a short, fixed RC time constant (0.2 millisecond). As before, the output is always positive except for a short drop to zero at the rising edge of the output from stage 2. Note now, however, that the output from stage 3 is synchronized not with the input to stage 1, but with the point where the decaying wave-

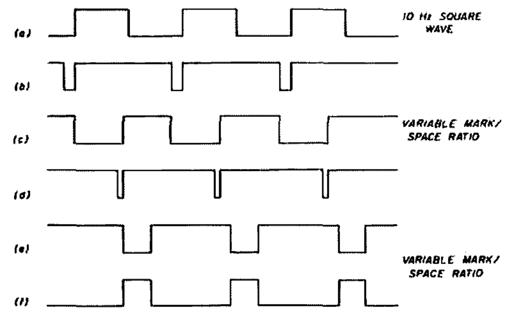


fig. 6. Waveforms for circuit in fig. 5.

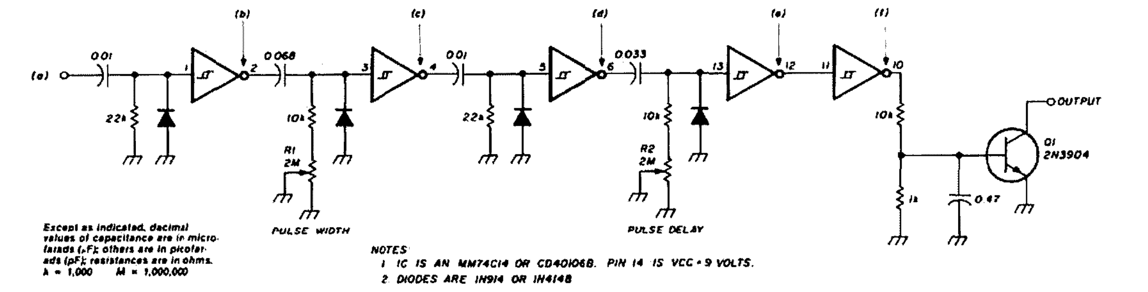


fig. 5. Delay and pulse-width circuits. Each device should be bypassed with a 0.01 μF ceramic capacitor with short leads.

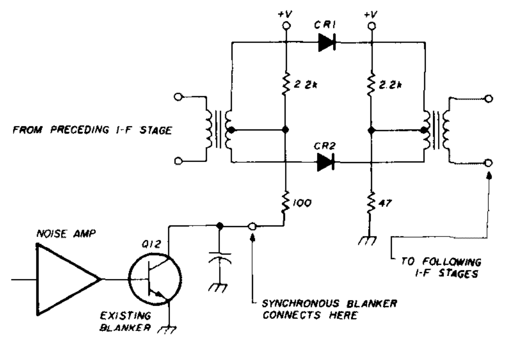


fig. 7. Simplified ICOM IC-701 noise blanker circuit (earlier models), showing point where synchronous blanker is connected.

form triggered the Schmitt in stage 2 to rise back to its positive value. This point is set by the variable RC constant, and thus by the 2-megohm potentiometer, R1.

In other words, at the output from stage 3, we have a brief negative-going spike whose phase with respect to the fixed, crystal-locked 10-Hz square wave input to stage 1 can be varied over a whole period (0.1 second) by R1.

Stage 4 is similar to stage 2; a half-monostable with a variable RC time constant. As with stage 2, the output is a negative-going pulse whose width is set by potentiometer R2. This is the pulse whose width determines how long the blanking goes on; that is, the blanking control pulse. The final Schmitt trigger circuit is merely used to invert the output pulse before it is applied to transistor Q1. The waveforms at various stages in the circuit (identified by letters in the circuit diagram) are shown in **fig. 6**.

Thus the final output from stage 4 is a pulse whose phase with respect to the fixed crystal-locked 10-Hz square wave can be varied by potentiometer R1, and whose width is set by potentiometer R2. This pulse is applied to the base of transistor Q1 through a current-limiting resistor. The pulse switches Q1 off and on, which allows it to alter the bias on the transceiver noise gate diodes, and hence blank the receiver.

IC701 blanker

A circuit showing the noise gate in the earlier model ICOM IC-701 is given in simplified form in **fig. 7**. The noise amplifier generates a control pulse that turns on transistor Q12 on the rf board. This action reverses the bias on diodes CR1 and CR2, and the signal is temporarily blocked from any further progress down the i-f chain. If Q1 of the synchronous blanker is connected in parallel with Q12 of the ICOM rf board, then the two transistors can operate independently of each other. In the ICOM it is a simple matter to tap into the rf board at the noise-blanker stage with a short length of coax to connect it to the external synchronous blanker.

Circuit diagrams of the Kenwood TS-820 and TS-520, and the Yaesu FT-75 suggest that a similar approach should work, and no doubt there are many others.

The newer ICOMs, however, use a 74LS123 to control the gate diode bias, and putting Q1 across the output of this device is not a good idea. In this case it would be necessary to use a circuit similar to that given in **fig. 8**, which involves a bit more tinkering and an extra 74LS01 IC.

adjustments

The main adjustment needed for the synchronous blanker is to ensure that the oscillator is accurately set. Trimmer capacitor C1 in **fig. 2** is used to tweak up the oscillator. The easiest way to do this is with a precision frequency counter. Pin 7 of the MM5369 in **fig. 2** is a test output at the crystal frequency. This should be set to 3.57954 MHz. Alternatively, if you have an accurately adjusted quartz clock using the MM5369 oscillator, it is possible to zero beat the two pin 7 outputs using a dual-beam oscilloscope.

The only other check necessary is to ensure that the waveforms look something like those shown in **fig. 6**.

how to use the circuit

The synchronous blanker is operated manually using the two potentiometers. When the Woodpecker makes its presence known, set the width control to about half way (corresponding to about 25 percent blanking of the incoming signal), and adjust the delay control until the interference is reduced as much as possible. Then readjust the width control to retain the blanking while attenuating the desired signal as little as possible. If all is well you should notice a significant reduction in the effect of the

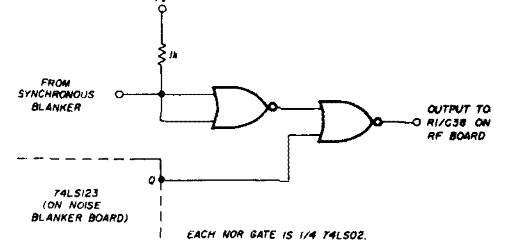


fig. 8. Modification to suit newer ICOM IC-701.

Woodpecker. If the oscillator is properly adjusted to give an accurate 10-Hz signal, the blanker should stay in sync with the Woodpecker for long periods without the need for readjustment.

A word of warning, however. While individual Woodpeckers stay synchronized for quite a long time, and even when returning after an absence will still be in sync, there are often occasions when more than one of the transmitters are operating in tandem. Under these circumstances, frequent readjustment is necessary and can be very tedious. Also, when the Woodpecker pulses are long and shaggy, it is necessary to blank so much of the incoming signal that intelligibility suffers severely. Under these circumstances, you have three choices: wait patiently, QSY, or go QRT!

Nevertheless, there are also times when the synchronous blanker is little short of miraculous. However, most of the time it falls somewhere between the two conditions, and provides a degree of respite.

conclusion

Most likely there are improvements that *can* be made to the circuit. The purpose of these articles is to draw attention to the possibilities of synchronous blanking, and see what others make of it.

In the next article in the series I discuss a further development of the circuit, which uses blanking in the audio stage. This obviously has the disadvantage that it does not overcome the AGC swamping effect of the Woodpecker; however, it can be fitted to any receiver, with or without noise blanker, with no need to get into the receiver circuitry.

references

1. *CMOS Databook*, National Semiconductor, 1978.
2. *CMOS Cookbook*, Don Lancaster, Howard Sams and Co., 1977.

appendix

The following was provided by Len Anderson, an assistant editor for *ham radio* and a contributor to our "Digital Techniques" series. Information is given on locating components, and some substitute devices are suggested. Also offered is an idea for using two chips to allow 10- or 16-Hz pulse switching. **Editor.**

component parts and alternates

All components should be available from many local and national sources. The MM5369 oscillator/divider is available from Radio Shack (part 276-1769). The MM5369 comes in three flavors, and an alternate is described below. The three versions are:

MM5369AA 60-Hz output (described by author)
MM5369EYR 50-Hz output (following divider must change)
MM5369EST 100-Hz output (following divider must change)

A suitable replacement could be the Intersil ICM7207 or ICM7207A, usually used with the Intersil ICM7208 counter IC to make a two-IC frequency counter. Source is Poly Paks or Newark Electronics.

The oscillator/divider could also be a part of a clock display using a National Semiconductor MM53107 clock chip. The MM53107AA has an auxiliary 60-Hz output; the MM53107FDU has an auxiliary 100-Hz output (divider change necessary). Caution: the MM53107 requires a 2.097152-MHz crystal and operates with a *2-6 volt* supply. The crystal can be obtained from Newark.

The 3.58-MHz crystal can be any NTSC TV color-oscillator crystal. The circuit will tune series or parallel resonance.

The CD4018B Johnson counter chip is a garden-variety CMOS device available from many sources. See **fig. A-1** for a suggested circuit to allow 10/16 Hz switching using two chips.

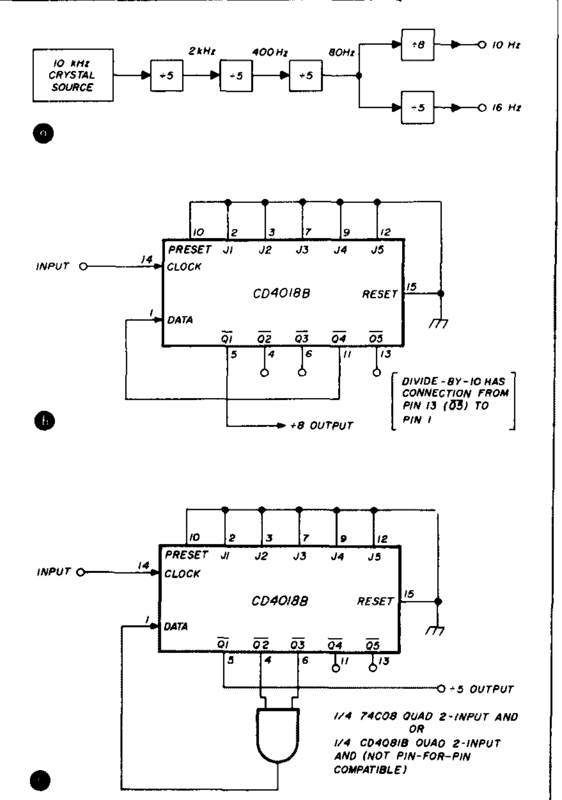


fig. A-1. Suggested circuit to enable 10- or 16-Hz pulse switching. The over-all counter chain is shown in *A*. The CD4018B is shown as a divide-by-eight and divide-by-five circuit in *B* and *C* respectively.

The hex Schmitt inverter can be either a 74C14 or a CD40106B. Both are CMOS and pin-for-pin compatible. Diodes in the delay and width circuits can be 1N914 or 1N4148. Both are small-signal, high-speed devices, readily obtainable. The 2N3904 can be replaced by several general-purpose NPNs; 2N3903, 2N4123, 2N4124, Motorola MPS2222 or MPS6514, or 2N2222.

alternative 10-Hz source

An existing frequency standard using a 1-MHz or 100-kHz crystal oscillator can be used as the timebase. Dividers must be used to get the 10-kHz repetition rate. North American power-line voltage can also be used as the 60-Hz standard. It will vary as much as ±0.1 percent only during changes in power flow (afternoons) but will otherwise be quite stable.

ham radio

an improved memory
for the versatile CW identifier

A better memory IC — the 1702A EPROM — in this follow-up to a previous article

An earlier article in *ham radio* entitled "Versatile CW Identifier"[1] resulted in a tremendous reader response for which I am most grateful. One improvement that I've pursued is the use of a different memory IC in place of U3, an 82S126. Two reasons prompted me to seek a replacement for this chip. The first is the general unavailability of the 82S126 because of its age, and the second is the fact that it cannot be reprogrammed. By changing to a 1702A ultra-violet (UV) erasable programmable-only memory (EPROM), I can now more easily obtain the chips, reprogram them and, as an added benefit, have double the memory capacity.

the 1702A EPROM

The 1702A EPROM is a 2K-bit device arranged as 256 bits by 8 (in contrast to the 82S126, which is 256 by 4). This means that twice the number of messages can be programmed. The 1702A retains the information programmed into it when power is removed as does the 82S126, but by exposing the window on top of the 1702A to short-wavelength UV light for several minutes, all memory locations can be erased, and the chip is ready to be reprogrammed.

A programming device for the 1702A is fairly complex and expensive. Articles have been written describing its construction.[2,3] However, as with the 82S126, I am offering the benefits of a computer-controlled programmer that I've built (see **table 1** for more information). I ask only that the messages you request to be burned onto the 1702A follow the format outlined in reference 1 — with the only exception being that word spaces can be shortened to six bits instead of seven to accommodate a slightly longer message than would otherwise be possible.

table 1. Parts list for the improved memory circuit.

quantity	description
1	16-pin wirewrap socket
1	24-pin wirewrap socket
1	1702A ultraviolet erasable PROM
	wirewrap wire
1	vectorboard

Notes:
1. Those with 1702A chips may have them programmed by the author for $2.00.
2. Adapter kits, including all parts and programming of the 1702A, are available for $10.00.
3. Complete CW ID kits, with 1702A and adapter instead of 82S126, are available for $35.00.

All prices are postpaid. Allow 4-8 weeks for delivery. Write Michael J. DiJulio, 97 Woodside Road, Maplewood, New Jersey 07040. Please include a self-addressed stamped envelope for all inquiries not accompanied by an order.

modifications

I designed the new circuit so that anyone who has built the original unit can add the new chip easily. The modification consists of wiring a small adapter board, which consists of a 16- and 24-pin socket. In addition to this board, one part needs to be rearranged on the CW identifier board to provide the proper voltage interface to the 1702A. The 1702A requires both +5 volts and −9 volts (actually −7 to −9 volts will do).

A problem arises here, as the only voltages presently available on the board are +12 volts and +5 volts. Some type of dc-to-dc converter is needed. In the interest of simplicity, I used a little trick to obtain the two voltages without adding any parts. By isolating the +12 volt source ground from the system of the board, a separate +5 volt and −7 to −9 volt (depending on the +12 volt supply) referenced to the board ground can be made available (see **fig. 1**).

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To accomplish this modification, unsolder the 82-ohm 1W resistor (*R5*) and insert it, on end, into the holes originally used for the +12, −12 volt supply input (see **fig.** 2).

Cut a 4-inch (10-cm) piece of wirewrap wire and insert it into the hole originally occupied by *R5* that still connects to one end of *R5*. This wire is now the −7 to −9 volt supply line, which will go to the plug-in board. Attach a length of black hookup wire to this point by tack-soldering it to the island under the board. This is the −12 volt supply line (ground of the host vehicle, radio, or power supply).

Connect a length of red hookup wire to the other hole formerly occupied by *R5*, which is still connected to the cathode of *CR1*. This is the +12 volt connection that goes to *S1*. The important thing to remember from now on is that the −12 volt supply line (+12 volt ground return) must

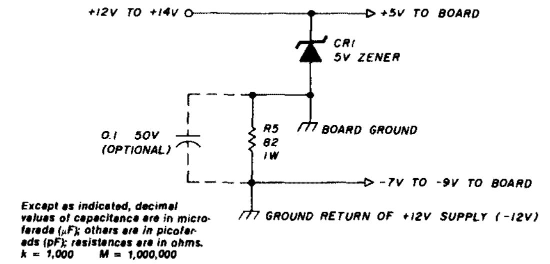

fig. 1. Power-supply modifications to provide −7 to −9 volts to the adapter board.

never be connected to the ground on the PC board! To do so will short out *R5*, disabling the −7 to −9 volt supply and almost certainly destroying *CR1*.

the ground system

You may ask how proper connection from the audio and keyer output jacks to the radio can be made with this seemingly haphazard ground system. Remember that the isolation between the two grounds is just an 82-ohm resistor, which, for the most part, will not alter the level of audio to the radio. However, for the purist a 0.1-microfarad capacitor may be shunted across *R5* to provide a more complete return path for the audio. With regard to the keyer output, in the original design a key closure looked like a 5-volt source in series with the same 470-ohm resistor; now it will look like a 12-volt source in series with the same 470-ohm resistor. The extra voltage should make no

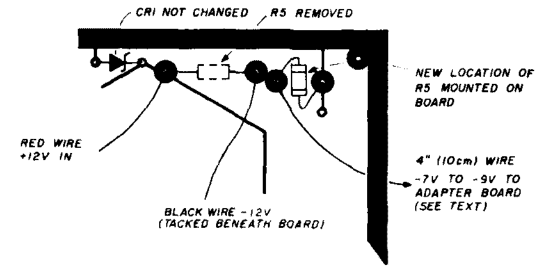

fig. 2. Details of the modifications made to the CW Identifier board to accommodate the new IC.

difference to the grid-block keying circuit of the transmitter.

As far as activating the circuit is concerned, *S1* can be replaced with a switched source of +12 volts such as the B+ line of the transmitter strip of the radio. Or if all that's available is the PTT line to ground, then replace *S1* with a piece of wire and use the PTT line to switch the −12 volt connection (the black wire previously mentioned). To summarize, no feature or performance is lost by modifying the power supply. However, be sure to isolate *all* ground board connections, such as the perimeter trace around the board, from the radio's ground system.

board construction

I toyed with the idea of laying out a PC board for the plug-in adapter board but felt that it was more trouble than it was worth. The simplest method for building the board is to obtain a 1.2 x 2.0-inch (30.5 by 50.8 mm) piece of perfboard with 0.1-inch (2.5-mm) hole spacing. Into this board, insert the 16- and 24-pin wire wrap sockets (fig. 3).

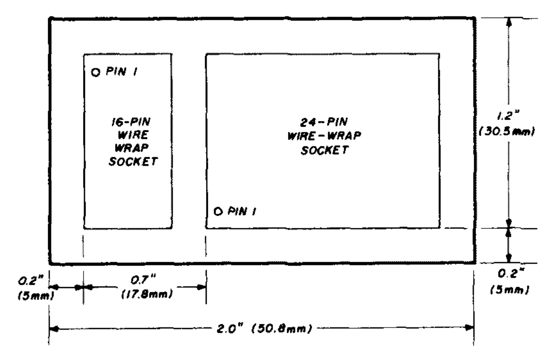

fig. 3. Top view of the plug-in adapter board showing arrangement for the 16- and 24-pin wirewrap sockets. Material is perfboard with 0.1-inch (2.5-mm) hole spacing.

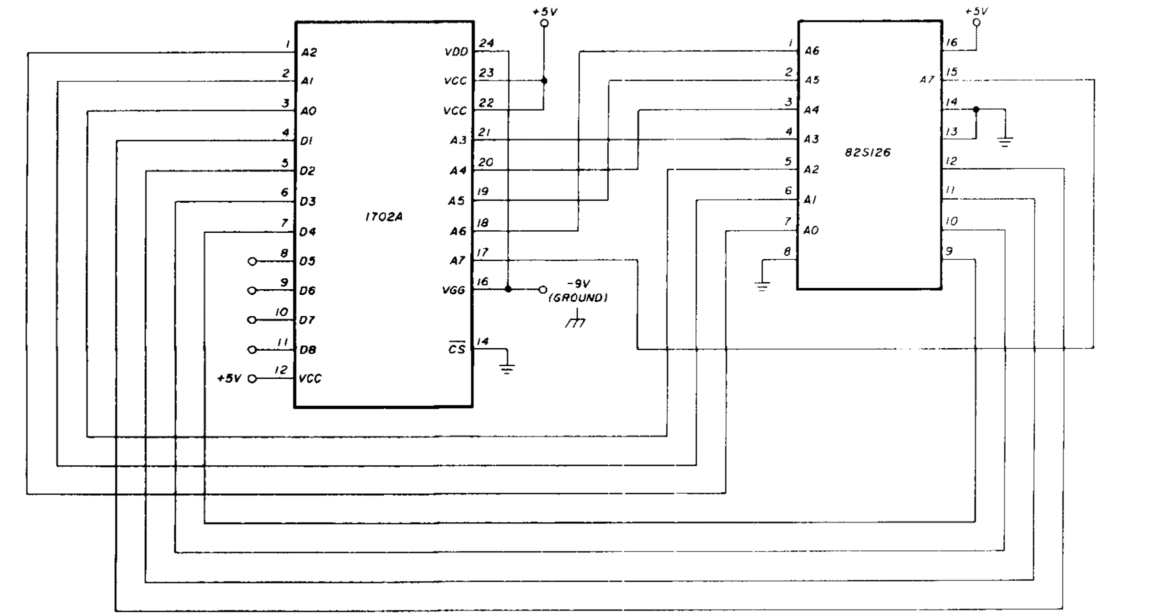

fig. 4. Schematic diagram of the adapter board for the CW identifier.

Using wire wrap wire and tools, connect the pins as indicated in **table 2.** (See also the schematic, **fig. 4.**)

Don't forget to connect the 4-inch (10-cm) piece of wire-wrap wire previously connected to *R5*. Instead of wire wrapping, the wire may be wrapped once around the pins and soldered to the pins close to the socket. Snip off the excess pin length (that is, just above the wire connection) on all pins of the 24-pin socket except for pins 8, 9, 10, and 11, which should be left at a length of 1/4 inch (6.4 mm).

table 2. Wirewrap connections between the 16- and 24-pin devices.

16 pin socket	→	24 pin socket
1		18
2		19
3		20
4		21
5		3
6		2
7		1
9		7
10		6
11		5
12		4
14		14
15		17
16		12, 22, 23

Note: 16 and 24 to − 9 volts on main board.

Cut a small piece of thin cardboard measuring 1 by 1/4 inches (25.4 by 6 mm). Place this piece of cardboard on top of *Q1* and *Q2* to insulate the transistors from the adapter board. Now insert the 16-pin socket firmly into the socket that formerly held *U3* (82S126). Make sure pin 1 is lined up properly. Either the 82S126 or the 1702A may be inserted into this adapter. The original pads used for message selection are still used, but now pins 8, 9, 10, and 11 of the 1702A permit the selection of four more messages when the 1702A is used.

I believe this modification is a simple and worthwhile one, which will greatly improve the utility of the identifier.

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ham radio

This fine receiver
has been the target
of many design improvements:
here's another

Drake R-4C receiver
improved power supply

In keeping with our policy to provide the most recent information on updating equipment, we present this article on improvements to the popular Drake R-4C communications receiver. As author Klinman points out, the perfect receiver has yet to put in an appearance. The R-4C by Drake with its many features comes close to the perfect receiver. These modifications to the R-4C are easy to make, result in a significant operational improvement, and use a minimum of mechanical modifications to preserve resale value of the radio.
Editor

The perfect communications receiver has yet to be produced. The Drake R-4C approaches this ideal. With certain modifications it can be made into a real "performance" receiver. Among these are the addition of selective first i-f filters, improved product detector and audio modifications as described by Sherwood,[1] third mixer redesign with solid-state tube replacement,* an audio lowpass filter by Sartori,[2,3,4] and agc modification by Klinman.[5] I recommend that those using the Drake R-4B/C obtain the excellent summaries of updates to these receivers available from Sherwood Engineering and Sartori Associates.†

*While the "Solid Tube," a product of Sartori Associates, used as replacement for the 6EJ7 mixers in the R-4C does effectively eliminate the severe noise generated by the vacuum tubes in these circuits, it does noticeably reduce large-signal-handling capacity of the receiver.

†Sherwood Engineering, Incorporated, 1268 South Ogden Street, Denver, Colorado 80210; Sartori Associates, P.O. Box 2085, Richardson, Texas 75080.

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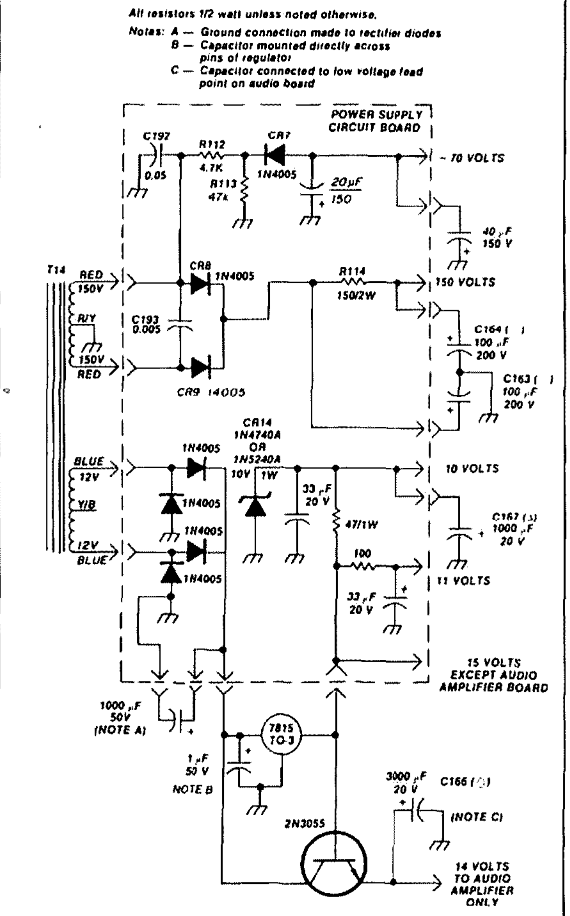
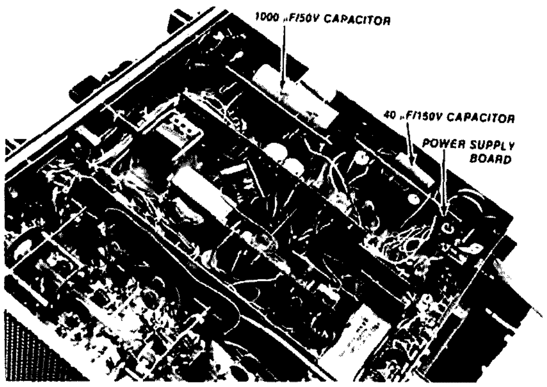


fig. 1. Schematic diagram of the Drake R-4C power supply. Numbered components refer to those in the original circuit.

A problem yet unresolved is the presence of excessive hum in the audio output. As pointed out by Sartori,[3] the original Drake power supply also generates *significant* heat under the R-4C chassis. In that article, Sartori described modifications to the power supply, but the suggested circuit produces marginal voltage for proper operation of the recommended monolithic voltage regulator. In addition, the circuit yields a regulated low voltage 2 volts lower than the original 14-15 volts.

Complete replacement of the R-4C audio amplifier with a monolithic audio power amplifier, as suggested by Sherwood,[6] will reduce the audio-amplifier average current drain on the low-voltage supply and



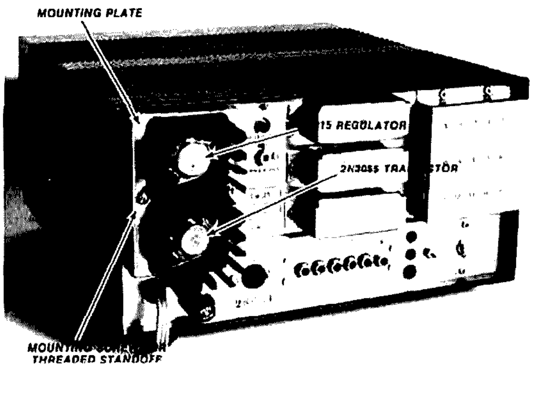
Underside of the Drake R-4C receiver chassis showing revised power-supply board and component layout.

regulator, but the monolithic circuit is difficult to stabilize and it can still require considerable peak current when driving a low-impedance load.* An advantage of the monolithic audio power amplifier is that it provides a significant amount — on the order of 30 dB — of power-supply ripple rejection.

As described here, it's a relatively simple matter to retain the original R-4C audio amplifier and upgrade the power supply.

revised power supply

Fig. 1 is the schematic diagram. A full-wave bridge rectifier with single-stage capacitor-input filter produces 25-30 volts, which is sufficient to power the 7815, a 15-volt monolithic voltage regulator. While increasing the average power dissipated by the power transformer, T14, no additional temperature rise of the transformer is noticeable. Because this supply voltage exceeds the voltage rating of the



Rear apron of the Drake R-4C receiver showing the voltage regulator and pass transistor, heat sinks, and homebrew mounting plate.

*The circuit may be stabilized by using Sherwood's output stabilization network, which is part of their audio-amplifier kit. Editor

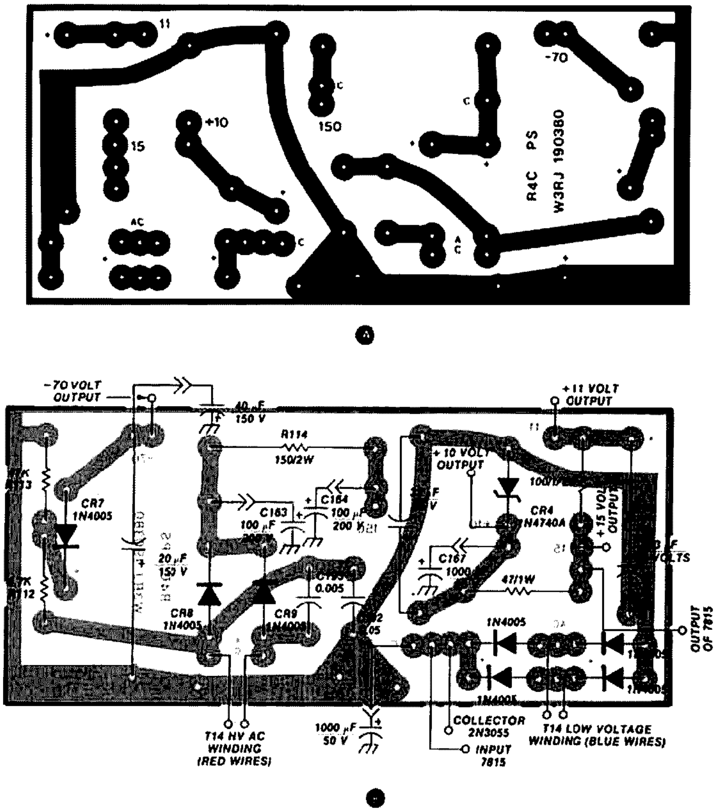


fig. 2. Circuit-board details. Full-size PC-board mask is shown in (*A*). Illustration (*B*) shows component layout.

existing filter capacitors, C166 and C167, an additional 1000 μF 50-volt electrolytic filter capacitor is required. The output of the TO-3-cased 7815 (or equivalent) 1-amp 15-volt regulator powers all 15-volt circuits *except the audio output stage.*

Power for the audio amplifier cannot be taken directly from the 7815 because of severe instability caused by the large inductive load of the audio output stage. A common base 2N3055* pass transistor provides the required isolation in addition to reducing the thermal load on the 7815 voltage regulator. One of the unused sections of the R-4C filter capacitor, C166, is used to further reduce the impedance of the 14-volt supply to the audio amplifier. A series resistor provides 11 volts for the PTO, and a zener diode provides 10 volts for the BFO and HFO circuits.

The remainder of the power supply is similar to the original circuit in the R-4C. An exception is additional filtering of the -70 volt supply to eliminate the last trace of hum in the receiver audio.

hardware

A board containing all components except the pass transistor, voltage regulator and 1-μF bypass capacitor, and the 1000-μF, 50-volt and 40-μF 150-volt filter capacitors replaces the original R-4C power supply board. The board mask and component placement are shown in **fig. 2**. Solder lugs, bent 90 degrees in the center and soldered to the board at the indicated locations, serve as mounting feet similar to those on the original board. Noteworthy details of construction are:

1. The low-voltage filter capacitor (a small size 1000-μF, 50-volt electrolytic) is mounted between the power supply or audio circuit board and the side of the chassis. It is secured to the chassis side wall with a plastic stick-on cable tie anchor. The ground lead

*Any NPN power transistor with V_{CEO} of at least 40 volts and collector current rating of 1 ampere will work in this circuit. (The 2N3055 is available for less than a dollar from several mail-order parts houses.)

of this capacitor must be returned to the ground foil of the power-supply board. A chassis ground to the filter capacitor cans, C163 through C167, while mechanically convenient, will lead to audio hum.

2. The 40-μF, 150-volt miniature electrolytic capacitor filtering the -70 volt supply is mounted between the power-supply board and the side of the chassis. It is soldered from the -70 volt output pad to the ground on the foil side of the board and is supported by its axial leads.

3. The centertap of the low-voltage winding (yellow/blue) of the power transformer, T14, is disconnected from ground, covered with heat-shrink tubing at the end to avoid short circuits to ground, and tucked out of the way along the chassis.

4. Connection between C166 and the 14-volt supply to the audio board is made to the low voltage supply solder lug directly on the audio board. The photograph shows the new power-supply board and component layout under the chassis.

The 7815 monolithic voltage regulator and 2N3055 pass transistor are mounted to the rear apron of the Drake R-4C on a small homebrew 2-1/2 × 3-3/4 × 1/2-inch (63.5 × 95 × 12.5-mm) open-bottom box.* This shallow box is fastened to the rear of the Drake R-4C with a pair of 1/2-inch (12.5-mm) threaded standoffs (photo). In this way, only two small, inconspicuous holes need to be drilled in the Drake R-4C. Wires are cabled and routed through a grommet inserted into one of the slots in the back apron and through the power transformer grommet, to the underside of the chassis. Small, finned heatsinks of the Walefield 680 type cool both voltage regulator and pass transistor.

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*This miniature open-bottom chassis can be easily fabricated from 1/16-inch (1.5-mm) aluminum sheet. Alternatively, the regulator and transistor may be mounted on a flat rectangular 2-1/2 × 3-3/4-inch (63.5 × 95-mm) plate. The 1/2-inch (12.5-mm) lip covers the electrical connections to the regulator circuit.

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operation upgrade

The fourth part in a continuing series designed to help you upgrade your ticket

In part three we discussed some of the active electrical devices and their uses. Active devices alter the voltages or currents applied to them in some way. Usually, the resulting currents and voltages are nonlinear, or distorted in waveshape to a greater or lesser extent. The active devices we covered were vacuum tubes and solid-state diodes. This month we will discuss shunt regulation, junction transistors, series regulation, special semiconductor diodes, FETs, SCRs, and triacs.

simple shunt regulators

To produce low-impedance (constant voltage) power supplies, it is necessary to add some form of voltage regulation. If a regulated 12-volt supply is required, it may be necessary to use something like a 20-volt unregulated dc supply and add regulation circuits between the unregulated voltage and the load.

A simple shunt regulation circuit uses a zener diode. This is a diode which has heavy doping of its semiconductor materials. In its forward direction it acts much like a normal semiconductor diode. As the inverse voltage is increased across a zener diode a point will be reached (the zener, or avalanche, voltage) where the diode suddenly allows current to flow in the reverse or inverse direction. Such an inverse avalanche current in a normal diode would destroy the crystalline form of the semiconductor materials and ruin the diode. But the zener will withstand whatever current it is manufactured to handle. A diagram of a zener-diode-regulated 12-volt power supply is shown in **fig. 1**. If the zener is manufactured to pass 1 amp of current safely, series resistor R_s should have the necessary value to pass not only 1 amp, but at the same time to produce a voltage drop across it of 20 volts minus 12 volts, or 8 volts. Therefore the

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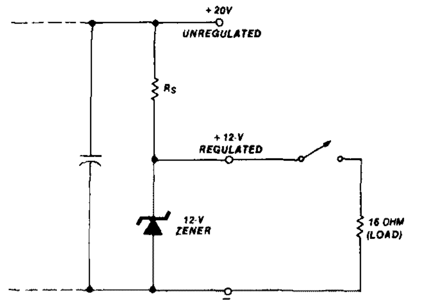

fig. 1. Using a zener diode to provide a regulated 12-volt dc output.

value of R_s is computed to be $R = E/I$, or 8/1, or 8 ohms. Its wattage rating would have to be at least $P = EI$, or 8(1), or 8 watts. Any 8-ohm resistor with a power rating over 8 watts would be satisfactory.

If a 16-ohm load is now connected across the zener's 12-volt voltage-drop, the current for the load would be $I = E/R$, or 12/16, or 0.75 amp, leaving the zener with 0.25 amp flowing through it. Since the zener still has 12 volts across it with 0.25 amp flowing through it, while the load is drawing 0.75 amp, the current through R_s must still be the same as with no load. The load can vary up and down from its 16-ohm value quite a bit without producing any change in the voltage across it. However, if the load increased (lowered resistance) to an effective 10 ohms, the zener would lose its control. Now the total resistance across the 20 volts would be 8 + 10 ohms, or 18 ohms. With 18 ohms and 20 volts the current would be $I = E/R$, or 20/18, or 1.11 amps. With 1.11 amps through the 10-ohm load, the voltage-drop across the load would be $E = IR$, or 1.11(10), or 11.1 volts. This is below the 12-volt zener voltage of the diode and it would no longer be carrying current and could no longer hold the output voltage at 12 volts. (We have disregarded the fact that the 20 volts would reduce under load.) If R_s were made 5 ohms instead of 8 ohms, the zener would regulate the 10-ohm load for reasonable variations, but if the load were disconnected or lightened excessively the current through R_s and the zener would increase and possibly burn out the diode. For many low current circuits, zener diodes do a good job of voltage regulation.

A similar type of regulating circuit is used with higher-voltage vacuum-diode-rectifier power supplies. Instead of zener diodes, they use gaseous voltage regulator (VR) tubes. These tubes have two metal elements in them, and are filled with a gas such as neon. At about 90 volts neon ionizes (and glows) and allows current to flow through it, but at a voltage-drop of approximately 75 volts across the tube. Over a current range of 5 to 35 mA a VR 75 tube will hold its voltage-drop at close to 75 volts. Thus, VR tubes can be used to regulate loads that vary between 5 and 35 mA. VR tubes come in 75-, 90-, 105-, and 150-volt values. To regulate a 300-volt output, two VR-150 tubes in series could be used. The unregulated supply must provide a no-load voltage of about 360 volts to produce the required initial ionization to start current flowing in the VR tubes in series to regulate 300 volts. (Similarly, two 12-volt zeners in series can be used to regulate to 24 volts.)

junction transistors

One of the transistors in use today is the bipolar junction transistor. We will call it a BJT to differentiate it from a field-effect transistor, or FET. A BJT is made up of three pieces of P and N semiconductor, somewhat as shown in **fig. 2.** In this particular NPN device there is a single thin P-material section between two pieces of N-material. Note the similarity of this triode (three-element) circuit to the VT (vacuum tube) triode circuit — but also note the differences.

The collector (C) circuit supply, V_{CC}, tries to forward-bias the emitter-base (EB) junction, since it has its negative terminal to the lower N element. But the upper PN junction is reverse biased by this same V_{CC}. As a result, no collector current (I_C) can flow. *In* this circuit the lower PN junction is being forward biased by the base power supply, V_{BB}. With the EB junction forward biased there is a current of electrons spreading out in the P material trying to find a path through the relatively poorly conducting semiconductor material to get from the emitter to the base connection. In spreading out looking for positive holes to use as stepping stones through the P material, some of these electrons move into the barrier area of the upper PN junction. Electrons in the upper barrier area cancel the barrier effect there, thus allowing current to flow from emitter to collector. The more emitter-base current that flows the more the base-collector

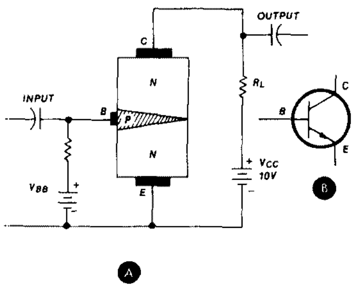

fig. 2. (a) Basic bipolar junction transistor in an amplifier circuit. (b) Symbol of an NPN type BJT.

barrier is cancelled and the greater the emitter-collector current can be. If the EB current decreases, so does the EC current. In a transistor of this type it may be found that a small EB current change in the input or base circuit can produce a 100 times greater EC current change in the output or collector circuit. This represents an amplification of current variation (h_{FE}), which is somewhat similar to the voltage amplification (mu) that occurs in a VT triode. We say the VT is voltage actuated, because voltage variations in the grid circuit control output circuit current (and power). In a BJT it is current changes in the input base circuit which control output current, so it is said to be current actuated.

Since the EB and the EC currents are both in the same direction through the emitter, the emitter current is always equal to the sum of the base and the collector currents, or $I_E = I_B + I_C$.

When amplifying ac signal currents, normally shown by lower case letters, the ratio of i_c/i_b is known as beta (β). On the other hand, the ratio of i_c/i_e is the alpha (α) gain of the transistor. At higher frequencies the alpha value decreases. The frequency at which it decreases to 0.707 (also known as 3 dB decrease) of its value at 1000 Hz is known as the alpha cut-off frequency (f_{hFB}).

Rather than using a separate battery or supply to produce the forward biasing current of the base circuit, it is simpler to run a relatively high value of resistance (100 to 250 kilohms) from $+V_{CC}$ directly to the base. This is shown as R_1 in **fig. 3a**. The value of this resistor is that required to reduce the forward biasing base current to about 1/100 of the normal I_C at which the transistor is to operate. For example if I_C is to be 0.005 amp, then I_B should be $0.005 \times 1/100$, or $0.00005\ A$, and $R_1 = E/I$, or $10/0.00005$, or *200,000 ohms*. (Consider the EB junction to be essentially zero ohms.)

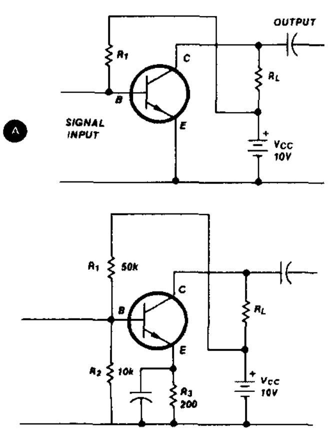

fig. 3. (a) Simple forward biasing method for a BJT amplifier. (b) Improved biasing circuit for a BJT.

While this simple biasing circuit will work, a far more satisfactory circuit, and the one generally used, is shown in **fig. 3b**. One of the difficulties with transistors is that they are made of semiconducting materials which always have a positive temperature coefficient (+TC). As the BJT operates, its I_C tends to heat it and it becomes a better conductor, so more current flows and it heats still more. If this cycle continues it can result in thermal runaway and the junctions of the BJT may melt. In the circuit of **fig. 3b**, the voltage divider biasing provided by R_1 and R_2 gives a more stable biasing. When I_C flows up through R_3 it produces a voltage-drop across this resistor. The voltage developed is negative at the bottom and positive at the top of R_3. When considered in series with R_2 and the base circuit, this voltage-drop will be seen to be a reverse bias for the base, which tends to reduce I_B and therefore I_C. So, with this network of resistors, when I_C begins to increase due to thermal effects, the reverse bias increases and the rise in I_C is held in check. However if the BJT is allowed to heat too much it may still self-destruct, and it can do this unbelievably fast! The ratio of R_1 to R_2 is usually about 5/1, perhaps being 50,000 and 10,000 ohms as the working values. R_3 is usually in the neighborhood of 200 to 500 ohms in low-power circuits (less in high-power circuits).

The reverse bias developed across R_3 will also occur at whatever the signal voltage or current rate is, resulting in a lessening of the effective input signal and a lessening of the output signal from the whole "stage" (BJT and all the components). The capacitor C_1 acts as a filter capacitor and tends to hold the voltage-drop constant as far as the rapid signal ac frequencies are concerned, but has no effect on slow thermal variations. Its value will vary from 0.01 for rf circuits to several microfarads for audio-frequency circuits.

Thus far, we have discussed just one type of transistor, the NPN bipolar junction transistor. BJTs can also be made with a P-material emitter, an N-material base, and a P-material collector. They are then known as PNP BJTs. They operate just like NPNs, except that the collector bias voltage, V_{CC}, is negative toward the collector, rather than being positive as in the NPNs discussed so far. It is not unusual to see both NPN and PNP transistors used in the same circuit to take advantage of the *complementary action* of the two devices. The arrow on the symbol of a PNP transistor is reversed from that of an NPN.

Most transistors are low-power devices. When higher power is required, BJTs must be made larger and must have some means of keeping the base-collector junction from getting too hot. This is accom-

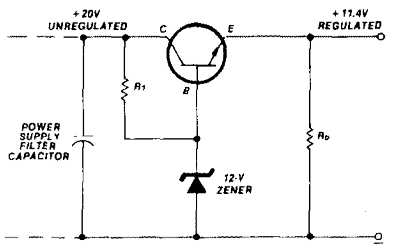

fig. 4. Series pass transistor voltage regulator circuit.

plished by using metal *heatsinks* on the transistors. Sometimes the heatsinks are built into the transistors and sometimes they must be added over the top of the body of the transistor. The bodies of power transistors are made with the collector element nearest the surface of the device to allow optimum cooling of the CB junctions.

series regulation

A BJT can be used to regulate the voltage output of an unregulated power supply, as shown in **fig. 4**. With R_b connected, there is a small I_C flowing in the transistor. A silicon EB junction will have a 0.6-volt barrier voltage-drop, making the output voltage equal to the 12 volts of the zener minus the 0.6 volt of the EB barrier voltage-drop for an 11.4-volt output. If a load is added, the I_C will increase and the voltage-drop across EB should increase slightly. This appears to the BJT as a greater forward bias and it passes more current for the load, and the regulated voltage approaches 11.4 volts again. However, such a regulation is never complete. There is always some change in output voltage when the load changes, which can be called an error voltage. In this simple series regulator the error voltage may be a fraction of a volt. If the error voltage can be amplified and fed to the base of the series regulator "pass" transistor, the output voltage variation will be better corrected and the power supply will be said to be better regulated.

In the series transistor regulator circuit of **fig. 5**, Q_1 is the pass transistor and Q_2 is the error voltage amplifier. R_B forward biases Q_1 and also acts as the collector load resistor for Q_2. R_Z is the zener resistor to hold it in conduction and provide a regulated reference voltage. The position of the arm on the potentiometer will determine the regulated output voltage within a limited range. If a load is suddenly applied to the power supply the output voltage of the supply tends to become lower. The base of Q_2 feels the reduced forward bias, which reduces its I_C. With less Q_2 collector current flowing through R_B there is less voltage-drop across it. The lessened R_B voltage-drop appears to the Q_1 base as a greater forward bias, and it passes greater I_C for the load. This re-establishes essentially the same voltage output as with no load. The regulation is perhaps 50 to 100 times better with this circuit than with the simpler circuit of **fig. 4**. The capacitor shown dashed is used as a filter capacitor to prevent sudden changes of voltage from being fed to the Q_2 base, which might cause excursions of the output voltage. Regulator circuits of this type are quite popular in transistorized Amateur Radio equipment. For better regulation under varying temperature conditions, added components are required which can complicate the circuits considerably.

Pass transistor voltage regulators can be made up into small *integrated circuit* (IC) packages about 3/8 × 3/8 × 1/8 inch (10 × 10 × 4 mm) that can regulate up to 1 ampere or more. They have three leads, one for the input unregulated positive voltage, one for the output regulated positive voltage, and one for the negative or ground lead. Additional 1-μF capacitors must be connected between input and ground and output and ground leads to prevent external ac fields from damaging the internal IC circuits. Regulator circuits made up of separate transistors, zeners, resistors, and capacitors are known as discrete circuits, indicating that they are constructed from separate, or discrete, parts.

Series regulation circuits for VT power supplies are similar to solid-state circuits. They require separate filament windings on the power transformer for the triode or tetrode pass tube and for any error amplifier. VR tubes are used as the reference voltage devices.

special semiconductor diodes

Besides the semiconductor diodes used as rectifiers and zener regulators, there are several other commonly used solid-state diodes.

The *tunnel diode* is a specially doped diode that has an unusual voltage-current curve. From zero

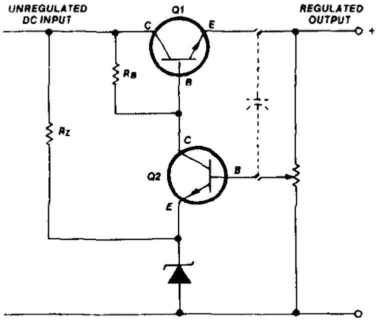

fig. 5. Pass transistor regulator capable of very good regulation.

volts forward bias to a fraction of a volt the current increases as voltage increases. Then, with a little more voltage increase the current begins to decrease. With still greater voltage increase, a point is reached where the current again begins to increase with an increase in forward biasing voltage. If operated in the downward sloping part of its curve it is said to be operating in a *negative resistance* condition, since current normally increases in a device when the voltage across it increases. Negative resistance can be useful in developing oscillator (ac generator) circuits and for special amplifiers with such diodes. The power output of tunnel diodes is quite small but they can operate at or generate extremely high frequency ac.

A *voltage-variable capacitor diode* (varactor, varicap) is used as a variable capacitor. You may remember that when reverse biased, a standard semiconductor diode develops a barrier area at its junction. The width of the barrier area depends on the value of the reverse bias voltage. Since a PN diode in a reverse biased condition is two conducting substances separated by a nonconductor (the barrier area), increasing the reverse bias increases the barrier width and reduces the capacitance between the two P and N materials. Thus, by varying the dc *reverse* bias on a varactor the capacitance it exhibits can be controlled. A varactor operated across an LC circuit can change the resonant frequency (that is, tune the LC circuit).

A *hot-carrier diode* (HCD) is one in which a semiconductor is grown against a piece of metal. Such a diode exhibits a rectifying action, but no barrier area is developed. As a result, the junction between semiconductor and metal can be instanteously made to pass or stop current flow. In the normal PN junction there are always a few misplaced electrons which act as "minority carriers." These must be swept out of the barrier area before the diode can turn on or turn off its current. This limits the speed of operation, or the frequency of the ac which the diode will rectify efficiently. Hot-carrier diodes are also known as *Schottky diodes*, and are useful up to super high frequencies.

A PIN *diode* has a P-material block separated from an N-material block by a thin intrinsic (I, or undoped) layer. These devices act as diodes up to a megahertz or so and then the intrinsic layer's slow action results in too much transit time delay. Above this frequency PIN diodes are useful because they have a high resistance when reversed biased, and a low resistance when forward biased. If inserted in a transmission line carrying high-frequency rf or microwave energy they can be made to effectively stop or allow the energy to pass down the line. We say the microwave energy transmission can be modulated (varied) by changing the PIN diode biasing voltages.

Point-contact diodes were the first semiconductor devices. The original ones were the crystal detectors of the early 1900s and are still available. They are somewhat similar to HCDs. They were improved during World War II and found use as detectors in radar sets. They are still used to detect microwave and other lower frequency rf signals. A point-contact diode consists of a fine wire cat-whisker touching a "sensitive" point on some form of metallic semiconductor. The original transistors were actually two separate point-contact diodes close together on a single piece of germanium or silicon.

A *light-emitting diode* (LED) radiates light when forward biased. All diode junctions when forward biased emit some frequency of radiation, usually in the invisible infra-red range. In most cases the radiation is shielded from the outside except at any exposed edge of the junction. With specially selected semiconductor materials it is possible to produce diodes that emit red, orange, yellow, green, or blue light waves. The diodes are manufactured to provide a maximum junction area to be visible, so that the light wave radiations will be emitted efficiently. LEDs also act as rectifying diodes, but have slightly higher barrier voltages than normal silicon diodes.

field-effect transistors

A type of transistor equally as important as the BJT is the field-effect transistor (FET). There are several types. One is the junction field-effect transistor (JFET). Another is the metal-oxide semiconductor field-effect transistor (MOSFET), of which there are several varieties.

The device shown in **fig. 6**a is a simplified N-channel JFET. It is called an N-channel device because there is an N-material channel between two P-material areas which are connected together electrically. At one end of the channel is a contact called the *source* (S). At the other end is the *drain* (D) contact. Any reverse bias in the *gate* (G) circuit (from G to $-V_{GG}$ to S) widens both barrier areas, which effectively pinches the channel narrower. The narrower the channel the more resistance it has and the less source-drain current that will flow with a given amount of drain circuit voltage ($+V_{DD}$). If sufficient negative bias is applied to the gate, the drain current (I_D) will be pinched off completely. If the gate is made positive, gate current will flow from gate to source. If you analyze this biasing action you will see that it is essentially the same as occurs in a vacuum tube as far as I_D and I_P actions are concerned. Thus, a JFET is a voltage *operated transistor*, whereas NPN and PNP BJTs are current operated. Within limits,

JFETs can be used in the same types of low-power circuits in which VTs are used, and vice-versa.

The JFET described is an N-channel type. If a JFET is manufactured with a P-channel between the two N-material areas or substrates, it is called a P-channel JFET. Basically the only difference in operation between N- and P-channel JFETs is the polarity of the V_{DD} and V_{GG} used with them. The symbol for an N-channel JFET is shown in **fig. 6b**, and for a P-channel JFET in **fig. 6c**.

An *insulated-gate* FET (IGFET, MOSFET, CMOS, COS/MOS, VMOS, etc.) has a thin N-channel grown on the surface of a P-material substrate, **fig. 7**. A metal contact is cemented to the N-channel with a thin layer of insulating material. If this metal gate (G) is made more negative, it attracts the positive holes from the P-material, which pinches the channel thinner, raising the N-channel resistance and reducing the I_D value. Variations of the gate voltage produce variations of the drain current, again very much like the operation of a VT, except that the gate may be driven positive and not draw any current from the channel because of the insulation layer. This is known as a depletion type MOSFET. There are also enhancement MOSFETs, which operate somewhat similarly except for the bias voltages used. In general, depletion MOSFETs use either a reverse direction bias similar to a VT, or zero bias. An enhancement MOSFET uses a forward direction bias voltage to which is added the input signal voltage to be amplified.

There are also dual-gate MOSFETs in which either or both gates can help to control the drain current, **fig. 7c**. These are used in *mixing circuits*, discussed in later articles.

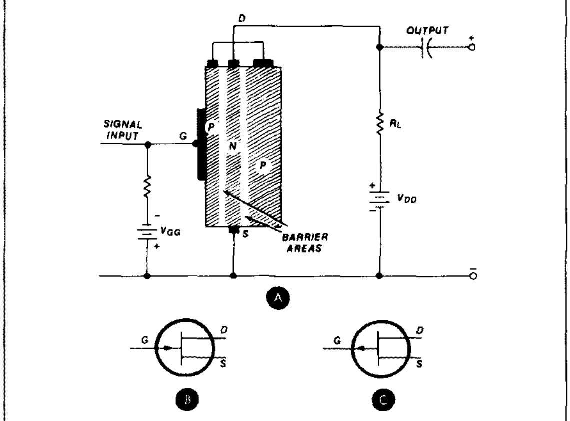

fig. 6. (a) Basic junction field-effect transistor in an amplifier circuit. (b) Symbol for an N-channel JFET. (c) Symbol for a P-channel JFET.

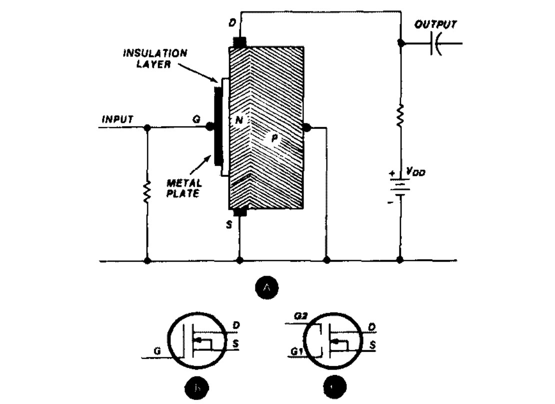

fig. 7. (a) Basic MOSFET in an amplifier circuit. (b) Symbol for an N-channel MOSFET. (c) Symbol for a dual-gate N-channel MOSFET. The P-type base substrate may or may not be connected to source or ground.

One of the newest high-frequency, high-power transistors is the VMOS, which is a special form of the MOS transistors. It gets its name from the V-shape channel used in it.

Note the similarities of the basic operations of the three elements of VTs, BJTs, and FETs:

VT		BJT		FET
Cathode (K)	=	Emitter (E)	=	Source (S)
Grid (G)	=	Base (B)	=	Gate (G)
Plate (P)	=	Collector (C)	=	Drain (D)

There is another type of transistor, called a *unijunction* transistor (UJT). It is a bar of N-material of about 10,000 ohms resistance, with a small emitter area grown on its side about half way down the bar. When the emitter bias is increased there will be a voltage at which the bar very suddenly becomes a good conductor. When the emitter bias is reduced there will be another value where the resistance of the bar very suddenly jumps back to the high resistance value. Unijunction transistors are not amplifying transistors, but can be used to trigger other circuits. They obtain their very fast change of state due to the negative resistance effect that occurs in them, which develops a form of regeneration. Regeneration in any device or circuit always tends to speed up the action time of circuits in which it is present.

SCRs and triacs

A *silicon-controlled rectifier* (SCR) is an NPNP, or four-layer semiconductor device. It has a cathode (K), an anode (A), and a gate (G), as indicated in the SCR circuit in **fig. 8**. In this circuit, with the switch open, regardless of which half of the ac is considered, at least one of the NPNP junctions will be re-

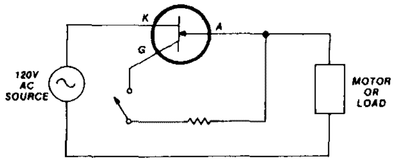

fig. 8. SCR as the control device in a motor circuit.

verse biased, preventing any current from flowing in the motor or load. When the switch is closed, one of the junctions that would normally be reverse biased is now forward biased and current can flow through the SCR, turning the motor. With an SCR, however, only current in one direction will be flowing through the load because of the one-way rectifying action.

A *triac* is another type of breakdown or *thyristor* NPNPN device. It acts like two SCRs back to back so that when the gate is activated it will pass current in both directions, terminal to terminal, through itself. The symbol of a triac is shown in **fig. 9**. In the applications discussed here these devices act as solid-state ac relays. They have other uses, such as phase controlling and light dimming circuits, for example.

fig. 9. Symbol for a triac.

FCC test topics

The following Advanced FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

- diodes: zener, tunnel, varactor, hot-carrier, point-contact, PIN, light-emitting, neon
- transistors: junction, unijunction, power, FET
- silicon controlled rectifier, triac
- voltage regulator circuits, discrete and integrated
- voltage regulator with pass transistor and zener diode to produce a given output voltage.

For additional information, see *Electronic Communication* by Robert L. Shrader, McGraw-Hill Book Co., available from Ham Radio's Bookstore.

ham radio

systematic design of crystal ladder filters

Using theory and experimentation to remove some of the mystery of filter design

Reports have appeared on the use of crystal ladder filters for SSB.[1,2] However, there doesn't seem to be any general awareness that modern network synthesis provides a theory and tabulated data that can be used for an approximate systematic design of these filters. Such a systematic approach is described here together with some practical hints for applying it. Several examples illustrate the approach. A simple strategem is also introduced to permit the use of crystals that would otherwise be unsuitable for crystal ladder filters.

a bandpass case in modern filter theory

A great deal of practical information on modern filter theory has been published since WW II. For design of narrow bandpass filters the ITT handbook[3] gives tables that are very easy for an Amateur to apply, particularly in this day of the inexpensive handheld calculator. Both to simplify the discussion and to indicate how this material applies to crystal ladder filters, start with the configuration of **fig. 1**. This figure is viewed as a cascade of coupled resonators and is a generalization of the familiar double-tuned circuit. In the case taken here, coupling is by common capacitance. The design tables in reference 3 provide the coupling coefficients between adjacent resonators and the operating Q of the end meshes.

In the circuit of **fig. 1** there are n meshes, coupled by the $n-1$ capacitors $C_{1,2} \ldots C_{n-1,n}$. The first mesh

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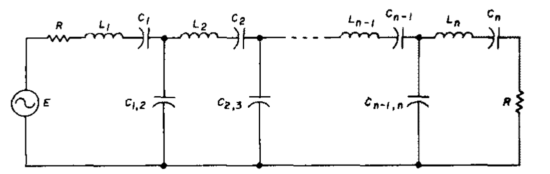


fig. 1. A bandpass ladder filter.

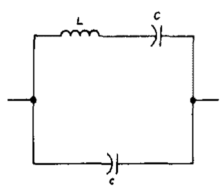


fig. 2. Crystal equivalent of fig. 1.

consists of the source, its internal resistance R, L_1, C_1, and $C_{1,2}$. The second mesh consists of $C_{1,2}$, L_2, C_2, and $C_{2,3}$ and so on. The first and last meshes are loaded with the equal source and load resistances R. Each mesh is assumed to resonate at the center frequency, f_0, when its adjacent meshes are open circuited. This provides a practical tuning method, though it is not used in the crystal filters to be discussed. To tune a given mesh, put a large resistance in series with each of the series LC branches adjacent to that mesh. "Large" means large compared to R. This reduces the coupling to the given mesh, leaving its neighbors almost open. Set the source E to frequency f_0 and adjust the given mesh for maximum output. Do this for each mesh. Readers who have adjusted over-coupled, double-tuned transformers will recognize this as the series circuit analog of what is done with such transformers (you shunt one winding with a low resistance and adjust the other winding for maximum response at the center frequency).

The values of the network components are determined from the tabulated data[3] as follows. Let df be the 3-dB bandwidth of the filter. Let $Q_1 = Q_n$ be the Q of the end meshes, $Q = 2\pi f_0 L/R \approx 1/2\pi f_0 CR$. These Qs are related to normalized q, tabulated in reference 3, by

$$Q_i = q_i \frac{f_0}{df} \approx \frac{1}{2\pi f_0 C_i R} \quad (i = 1,n) \tag{1}$$

The coupling coefficients between two adjacent meshes are $K_{i,i+1}$. These coupling coefficients are related to normalized $k_{i,i+1}$, again given in reference 3, by

$$K_{i,i+1} = k_{i,i+1} \frac{df}{f_0} = \frac{\sqrt{C_i C_{i+1}}}{C_{i,i+1}} \tag{2}$$

$$(i = 1,2 \ldots n-1)$$

The tables in reference 3 give sets of k and q for several mathematical filter shapes — in particular the Chebychev for various values of passband ripple including zero (the Butterworth limiting case) and for up to seven meshes. These tables apply to a wider variety of filters and configurations than that of **fig. 1**, and the reference is well worth reading. Notice that the special case under consideration is symmetrical: $q_1 = q_n = q$ and $k_{1,2} = k_{n-1,n}$ and so on. Although not the subject of this article, the process above leads to useful LC sideband filters at frequencies up to about a hundred kHz.

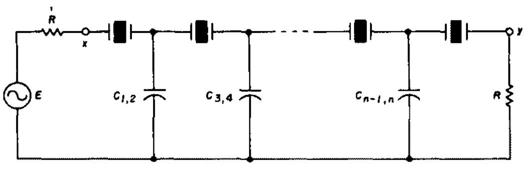


fig. 3. Simple crystal ladder filter.

To simplify further and to prepare for the crystal filter case, all the series branch Cs can be taken equal, say $C_1 = C_2 = \ldots = C$ and the meshes imagined tuned by small adjustments of L_i. Under these conditions the equations needed to carry out the design are, from **eqs. 1** and **2**:

$$R = \frac{df}{2\pi f_0 C q f_0} \tag{3}$$

and

$$C_{i,i+1} = \frac{f_0 C}{df k_{i,i+1}} \tag{4}$$

The tabulated q and the values of C, f_0 and df determine the source and load R. The tabulated $k_{i,i+1}$ for the chosen shape and the values of C, f_0 and df determine the coupling capacitors.

simple crystal ladder filters

In the neighborhood of its main natural frequency, a crystal looks like the circuit of **fig. 2**, where a small loss resistance can be ignored. The series and parallel resonant frequencies, f_0 and f_∞ are given by:

$$f_0 = \frac{1}{2\pi\sqrt{LC}} \qquad f_\infty = \frac{\sqrt{\frac{1}{C} + \frac{1}{c}}}{2\pi\sqrt{L}} \tag{5}$$

It turns out that C is very much less than c, so the two frequencies are related by

$$f_\infty - f_0 \approx \frac{C}{2c} f_0 \tag{6}$$

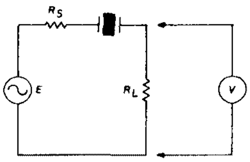


fig. 4. Measuring crystal C.

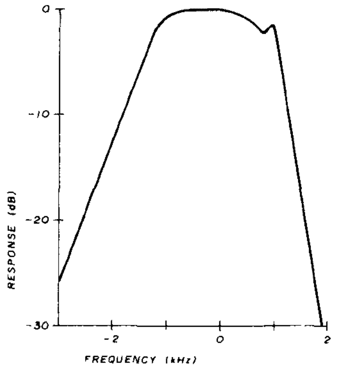


fig. 5. Response of four-crystal SSB filter.

For the time being, assume that f_∞ is sufficiently above f_0 to be well outside the passband of the filter to be designed. Under these conditions f_∞ and the crystal shunt c can be ignored. Then the configuration of **fig. 1** can be realized with crystals, as in **fig. 3**. (Design tactics when f_∞ is too close are discussed later.)

If all the crystals in **fig. 3** have the same f_0, the n meshes will still not be resonant at the same frequency. However, since the crystal C is very much less than $C_{i,i+1}$ in series with the crystal in each mesh, the mesh frequencies are not very different from f_0 and the meshes are almost correctly tuned, as required for the theory of **fig. 1**.

Since crystals come with L and C fixed, the crystal-filter design starts with C given, and **eq. 3** determines R, while **eq. 4** determines the value of the coupling capacitors. Manufacturers do not stamp the value of L, C and c on their crystals, but a good guess at C can be made from the setup shown in **fig. 4**.

If the crystal is driven by a grounded-base or a grounded-emitter amplifier, the source resistance, R_S, can be assumed to be the dc transistor load resistor. So that the crystal shunt c will not greatly affect the measurement, both R_S and R_L should be as small as convenient. Values up to one or two hundred ohms are adequate. The voltage across R_L is measured with an rf probe at the frequency of maximum response, f_0. Frequency is then varied above and below f_0 to find the frequencies where the voltage has decreased to $\sqrt{2}/2$ times the maximum first measured. The difference, df, between these two frequencies is then used in **eq. 7** to estimate C:

$$C = \frac{df}{f_0 2\pi f_0 (R_S + R_L)} \tag{7}$$

This measurement on some crystals marked 5724 kHz gave $C = 0.026\ pF$. The shunt capacitance can be measured at a frequency well away from f_0 by any capacitance-measuring scheme. For these crystals it is about $c = 6.2\ pF$. These values in **eq. 6** imply that f_∞ is about 12 kHz above f_0, which is safe to ignore.

Only six of these crystals were on hand, so a four-crystal filter was built, with the other two set aside as carrier crystals. The resulting filter is unsuitable in a receiver for battling 20-meter behemoths but is quite usable in ordinary communications. It is perfectly adequate in a transmitter; and in any event, it illustrates how the theory is applied.

measurements

My setup for measuring C and also for measuring the constructed filters is a bit crude and can be easily duplicated, and probably improved, by other home brewers. It consists of a transistor Vackar oscillator with buffer amplifiers to drive the filters and a diode probe connected to a very high-resistance dc voltmeter to measure output. Frequency is read on a home-made counter. Resulting measurements from the first design are used to re-estimate C, leading to a closer and usually final design.

experimental SSB filter

For the four-crystal filter with $f = 5724\ kHz$, choose $df = 2.5\ kHz$ and the 1 – dB ripple Chebychev shape. The table[3] gives $k_{1,2} = 0.638 = k_{3,4}$; $k_{2,3} = 0.546$ and $q = 2.21$. **Eq. 3** gives $R = 467\ ohms$, and **eq. 4** gives $C_{1,2} = C_{3,4} = 93\ pF$, and $C_{2,3} = 109\ pF$. This filter was assembled with $R \approx 470\ ohms$ and capacitors measured to about 5 percent from the junk box. My measurements indicated that the filter had a 3-dB bandwidth of about 1650 Hz and a maximum ripple of about 1.4 dB near the top of the passband. Instead of the four peaks of the theory, there was one peak near the top end and a very broad single peak over the rest of the passband.

If you believe in the theory, the experiment above tells you that the estimate for C from **eq. 7** is too high. I therefore guessed C to be about 0.005 pF less, namely 0.019 pF and recalculated $R = 639\ ohms$, $C_{1,2} = C_{3,4} = 68\ pF$, and $C_{2,3} = 80\ pF$. With the second round of coupling capacitors selected from

the junk box and the source and load R set near 640 ohms, the measured bandwidths were 2400 Hz at 3 dB, 2650 Hz at 6 dB and about 4740 Hz at 30-dB down. My rf measurements are certainly not reliable beyond 30-dB down. This filter has a 30- to 3-dB shape factor of about 2.0. For the 1-dB Chebychev characteristic it should be about 1.75, as obtained from the curves in the ITT handbook. However, this filter seems quite satisfactory, and its response is plotted in **fig. 5**. Since the coupling capacitors can be measured only to 2 or 3 pF, further work is not indicated.

Incidentally, as a general observation, changing the source and load resistors from the calculated values has only a small effect on the bandwidth but does change the passband ripple and skirt slopes. For lower R the ripple increases and the skirts steepen; for higher R the reverse results. Small changes in R can be used to make some final improvements if desired.

The filter characteristic plotted in **fig. 5** has one dip of 1.4 dB near the top of the passband. The loss of this filter, measured as the ratio of voltages at x and y in **fig. 3**, is about 2.6 dB (1 volt out for 1.35 volts in).* Considering the known deviations from the theoretical model, the agreement seems reasonably satisfactory. The meshes are not tuned to quite the same frequency, both because of the variations from crystal-to-crystal and the effects of the different coupling capacitances in each mesh.

analysis

The shunt c will cause the filter, even inside the passband, to deviate from that which would be obtained in the absence of c. The reactance of a crystal at any frequency below f_∞ is always *algebraically* greater than the reactance of the series LC branch alone, except where they touch at f_0. Between f_0 and f_∞ the crystal has a greater inductive reactance and rate of increase than the LC branch alone. Below f_0 the crystal has capacitive reactance, whose magnitude is less than that of the LC branch alone. The rate of increase of reactance below f_0 is also less for the crystal than for just its LC branch. These differences, though small near f_0, can be expected to cause deviations in filter shape from the theoretical curves for the filters of **fig. 1**. Furthermore, whatever these deviations are, they should have opposite characteristics above and below f_0. From the example of **fig. 5** it appears that the effect is to increase ripple above f_0 and to decrease it below f_0. At f_0 the shunt c has no effect.

If the crystals were shunted by an inductance that cancels c at f_0, I would expect passband shapes to agree with the theory for **fig. 1**. This is because the high reactance of the parallel-resonant circuit easily persists over the passband, making the net crystal reactance that of the series LC in this region. I hope to try the experiment some time when suitable coils can be found or wound. However, I would not use such a filter in practice, because values of f_∞ closer to the passband give better filter shape factors — a subject discussed in a later section.

*The editor and author are aware of the concept of insertion loss. The author finds the ratio of voltages at points x and y easier to measure and just as useful.

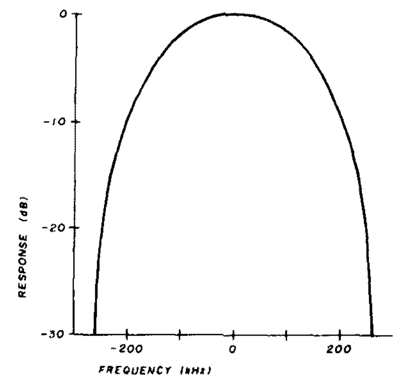


fig. 6. Response of four-crystal CW filter.

experimental CW filter

As a second example, here is a narrow CW filter, also using four crystals. These are type CR1A/AR marked 5910 kHz. Series C measures 0.0023 pF and shunt c about 4.5 pF. For this example choose $df = 200\ Hz$ and the Butterworth shape. The appropriate table in reference 3 gives $q = 0.766$ and $k_{1,2} = k_{3,4} = 0.840$; $k_{2,3} = 0.542$. **Eq. 3** determines $R = 517\ ohms$, and **eq. 4** determines $C_{1,2} = C_{3,4} = 80\ pF$ and $C_{2,3} = 124\ pF$. When this filter was built, the bandwidth turned out to be about twice what was expected. The series C was therefore re-estimated to be 0.0046 pF. The recomputed coupling capacitors are $C_{1,2} = C_{3,4} = 162\ pF$ and $C_{2,3} = 251\ pF$. The recalculated load resistances are 256 ohms. This filter was built with 160 and 250 pF from the junk box assortment of mica capacitors. The characteristic for this filter appears in **fig. 6**. The 3-dB bandwidth is a little under 250 Hz and a third trial seems unnecessary for my application. The 30-to 3-dB shape factor is about 2.0. The theoretical value for a Butterworth filter is about 2.4, so this filter has slightly steeper skirts than expected. As noted above, the skirts could easily be spread slightly and the characteristic made closer to the Butterworth shape by raising the terminating resistances to perhaps 400 ohms.

comments on CW filters

For a given bandwidth and number of resonators, the Chebychev design contains a trade-off between passband ripple and skirt steepness. For speech filters high ripple and steep skirts are probably preferable. As ripple is decreased so are overshoot and ringing, so it seems likely that for a narrow CW filter the Butterworth shape would be more satisfactory.

As a point of information, the ITT handbook also contains design data for Bessel filters. Bessel filters produce minimum distortion of pulse envelopes for a given bandwidth but have even broader skirts than Butterworth filters. The handbook contains theoretical curves from which shape factors can be read. The 30- to 3-dB shape factors for 1-dB Chebychev, Butterworth and Bessel filters using four resonators are 1.75, 2.4, and 3.5 respectively.

Anyone who has read advertisements for CW filters must have noticed that they have significantly higher shape factors than the same manufacturer's SSB filters. The above discussion may help to explain this observation. It seems to be customary to quote 60- to 6-dB shape factors for filters. Since I cannot measure reliably below about 30 dB, shape factors for 30 to 3 dB will be given when comparing results to theory. Readers who must have shape factors for other levels can easily estimate the theoretical values from the curves in the ITT handbook.

effect of crystal shunt capacitance

Hardcastle[2] points out that some crystals are unsuitable for the simple SSB filter of **fig. 3**. These are crystals for which f_∞ is too close to f_0. The passband spreads slightly above and below f_0. If the crystal f_∞s are too close, the filter's high-frequency cutoff will come "early" and the available bandwidth may be too narrow for SSB. I ran into this problem trying to use some of the crystals in the previously described CW filter for a six-crystal SSB filter at 5910 kHz. The recipe of the previous section was used but no amount of struggling with coupling capacitors or terminating resistances availed to produce a passband wider than about 1000 Hz. Taking the best estimates of crystal parameters, $C = 0.0046\ pF$ and $c = 4.5\ pF$, we find from **eq. 6** that f_∞ is about 3 kHz above f_0. Apparently this is too close. Incidentally, my CR1A/AR crystals are plated squares, supported on wires at diagonally opposite corners and are not the compression-mounted CR1AR crystals Hardcastle notes to be unsuitable. Nevertheless, my 5910-kHz crystals are equally unsuitable!

inductance coupling

An interesting experiment was made to test this notion about my crystals. First, notice that the mesh frequencies will be higher than the crystal f_0, since the crystal is in series with the coupling capacitors. This aggravates the effect of a too-low f_∞. Now, coupled resonator filters can be coupled just as well by common inductance as by common capacitance. The series inductances will lower the mesh frequencies, moving the passband away from the crystal f_∞. I happened to have several small encapsulated 26-μH chokes whose reactance at 5910 kHz is close to that of the appropriate coupling capacitors. Without changing anything else, the coupling capacitors in an unsuccessful trial filter that was 1-kHz wide were replaced by these chokes, whereupon the filter bandwidth went to about 4500 Hz. This verifies the cause of the trouble and suggests the two tactics to be discussed in the following sections. Common inductance coupling can apparently move f_0 sufficiently to make these crystals usable, and I plan some more careful trials. The value of coupling inductance could be directly calculated from an equation similar to **eq. 4**. An alternative is to calculate coupling capacitances from **eq. 4** and then replace them with the inductances with which they resonate at f_0. A minor problem arises because crystal shunt c and the coupling inductances form a highpass filter some MHz above the passband. A few high-Q LC circuits at f_0 should eliminate that response.

use of series inductance

Since series inductance lowers the f_0 of a crystal while leaving f_∞ fixed, why not just replace the simple crystal ladder filter by the configuration of **fig. 7**? The junk box happened to contain a number of small encapsulated rf chokes that had been measured as 62 μH shunted by 1.8 pF, so one was put in series with each crystal and the filter response roughly checked by watching the output voltage at point **y** in **fig. 7** as the VFO was tuned through the passband. Coupling capacitors were some left from one of the earlier trials with these six unsuitable crystals. For load resistances of 200, 300, 400, and 1000 ohms the 3-dB bandwidths were 2110, 1970, 1740, and 1670 Hz respectively. Except for the case of 1000-ohm terminations, all the shapes were reasonably flat on top. Filter loss varied from 13 dB with 400-ohm terminations to 19 dB with 200 ohms. This loss is computed from the ratio of voltages at points **x** and y in **fig. 7**.

For my projected use of this filter, a loss of 19 dB seemed excessive. Filter output voltage would be only a tad over one-tenth of the input voltage. For this reason no response curves were plotted. However, the shapes were good, and if a loss of this magnitude can be tolerated, the configuration is worth considering as a way to use crystals that are unsuited for use in the simpler configuration of **fig. 3**. To build such a filter I would determine the coupling capacitor

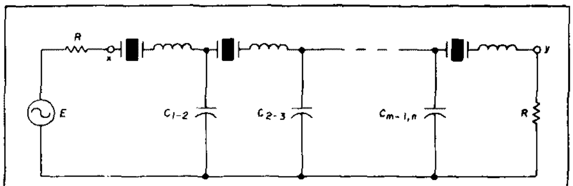


fig. 7. Crystal ladder filter with series coils.

values as for the simple **fig. 3** configuration but would use a resistance slightly lower than the calculated terminating resistance. The latter variation should compensate somewhat for the loss in the chokes.

use of shunt inductance

To introduce this point, recall both the cause of f_∞ and its effect on the filter. The cause, of course, is c of **fig. 2**. The effect is not only to interfere with the filter's upper frequency limit but also to produce an n-fold null in the filter's response, or a series of closely spaced nulls just above the filter's passband. This is the result of parallel resonances in the signal path. These nulls have the effect of steepening the high-frequency cutoff, as is clearly shown in Hardcastle's curves[2] and in **fig. 5**. This makes the simple crystal ladder filter better for LSB than USB.

Considering its source, f_∞ can clearly be moved by shunting the crystal with reactance. More capacitance would only move f_∞ closer to f_0. The effect of shunt inductance depends on the magnitude of the inductance. If the inductance is greater than the value required to resonate c at f_0, then the effect is to move f_∞ up, thus converting unsuitable crystals to suitable ones if moved far enough. To see why this should be so, notice that such an inductance cancels part of the shunt c at f_0. This inductance, with the cancelled part of c, is parallel resonant at f_0 and does not affect the operation of the series LC branch of the crystal near the passband. The residual, uncancelled part of c is, of course, smaller than the original c and combines with the series LC to produce a higher f_∞ than the original.

If the shunt inductance is less than the value required to resonate at f_0 with the shunt c, then the effect is to move f_∞ below f_0. One way to see this is to imagine the shunt inductance broken into two greater inductances in parallel, one of which is the value required to resonate at f_0 with c. This latter combination, as in the previous case, does not disturb the crystal operation near the passband, while the remaining portion of the shunt inductance combines with the series LC to produce an f_∞ below f_0. If f_∞ is pushed sufficiently below f_0, an unsuitable crystal can again be made suitable.

Useful values of shunt inductance will be on the order of the inductance required to resonate c at f_0. Let x be the inductance that resonates at f_0 with c. Let $x + dx$ be the value of shunt inductance actually used. Note that dx is not required to be small compared to x and may be positive or negative. The new f_∞ is then determined approximately by

$$f_\infty - f_0 = \frac{C(x+dx)f_0}{2c\,dx} \qquad \textbf{(8)}$$

or, solved for the unknown dx:

$$dx = \frac{x}{\dfrac{f_\infty - f_0}{f_0} \bullet \dfrac{2c}{C} - 1} \qquad \textbf{(9)}$$

Real coils have parasitic shunt capacitance that causes a slight difficulty in **eq. 9**. The values of inductance that will be called for with high-frequency crystals, roughly in the range 20 to 200 μH, can be expected to have shunt capacitances from 1 to 5 pF. An estimate of this shunt capacitance must be added to the crystal shunt capacitance to obtain the c and x used in **eq. 9**, resulting in a certain amount of imprecision and trial. Nevertheless, good estimates of the required shunt inductance are possible.

an example using eq. 9

Suppose for my unsuitable 5910-kHz crystals a new f_∞ is desired 10 kHz below f_0. Assume the coil will have 3.5 pF shunt capacitance. Using the crystal values of 0.0046 and 4.5 pF, we have $C = 0.0046$ and $c = 8$ in **eq. 9**. The inductance resonating with 8 pF at 5910 kHz is $x = 91\ \mu H$. Inserting all this into **eq. 9**, we get $dx = -13$. The inductance to use is therefore $x + dx = 78\ \mu H$. If, on the other hand, we want f_∞ 12 kHz above f_0, the result is $dx = 15$, and 106 μH is the value to use in the circuit. In the actual case 3.5 pF may overestimate the shunt capacitance of a 78-μH coil, so that slightly greater inductance might finally be used.

Eq. 9 will usually be used in two ways, neither of which suffers much from imprecise estimates of coil shunt capacitance. The first use of **eq. 9** is in moving crystal f_∞ sufficiently above or below f_0 to make unsuitable crystals usable and to produce the sharper cutoff on the desired side of the passband. The other use is to produce nulls at particular frequencies, as discussed in a later section. In that case, coils will be used that are adjustable in the neighborhood of the value calculated from **eq. 9**, and the nulls will be set to the desired frequencies whatever the actual shunt c.

To keep the record straight, when a crystal is shunted with inductance the combination has two

values of f_∞, one below and one above f_0. The approximation (**eq. 8**) applies to the one close to f_0.

Having *no small* handy chokes near the above sizes, I took the 62-μH chokes of the previous section's experiment and shunted them across the six crystals, producing the filter of **fig. 8**. From the discussion above it is clear that with all f_∞ below the passband, the filter should have its steeper cutoff at the low end and thus be better suited for USB, which is my application. The curve for the filter of **fig. 8** is given in **fig. 9** and indeed has a very sharp low-frequency cutoff. The shape is a good way from the 1-dB Chebychev, for example, yet it is quite useful. The bandwidths at 3, 6, and 30 dB are 2300, 2700, and 3900 Hz respectively; the 30- to 3-dB shape factor is about 1.7.

The subpeak just above low-frequency cutoff is 1.2 dB down from maximum response, and the trough just above it is 1.4 dB down from maximum response. If the carrier were placed at the 30-dB-down point, the small subpeak would correspond to an audio frequency of about 250 Hz. I'm sure this filter can be improved further, but lethargy triumphed.

It is interesting that when f_∞ is moved just outside the low end of the passband, the effect of shunt inductance on the passband shape is just the opposite of that of crystal shunt c on the simple filter of **fig. 3**.

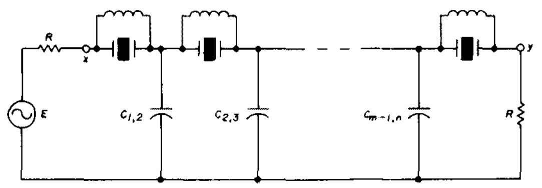


fig. 8. Crystal ladder filter with shunt coils.

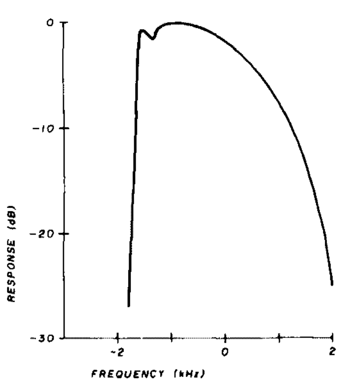


fig. 9. Response of six-crystal shunt coil SSB filter using "unsuitable" crystals.

Ripple increases at the low end and decreases at the high end. Without going into details, the deviations in the reactance of the crystal branch with shunt inductance from the reactance of the series LC branch alone are opposite from the deviations with crystal shunt c.

Terminating resistors used with this filter were 1000 ohms. The loss, as measured in the previous section, is 2 dB at the top of the broad peak. This shape and loss are so satisfactory for my use that further tinkering is not contemplated despite the departure from book shape. I calculate the new f_∞ to be about 2.5 kHz below f_0, taking into account the choke shunt capacitance of 1.8 pF. The six nulls crowd toward the low end of the passband just as the original six crowded toward the high end and prevented achievement of a bandwidth over 1 kHz. The coupling capacitors used in this filter are smaller than the theoretical values for a 2.5-kHz bandwidth, and the passband is shrunk at the low end.

Coils shunting the crystals introduce a minor hazard of which to be aware. Some MHz below the passband these coils and the coupling capacitors form a lowpass filter. Response there must be reduced by other means. Ordinarily there will also be some LC circuits at the filter frequency, and these should solve the problem. Also, to avoid unnecessary loss, the filter should be matched to the devices between which it operates. The hazard can be avoided by making these matching circuits high-Q tapped tanks or high-Q L networks (Q of an L network can be increased by replacing the series element by a series LC circuit or the shunt element by a parallel LC circuit.) Of course, this hazard will not occur if your crystals can serve in the simple circuit of **fig. 3**.

adjustable zeros

The discussion above of f_∞ and its manipulation suggest the possibility of using adjustable coils across each crystal and setting half the f_∞ to specific frequencies above the passband and the other half to specific frequencies below the passband. This can make a great improvement in shape factor and produce performance close to that of elliptic function filters. If the passband ripple is fixed and the minimum stop-band attenuation is fixed, then elliptic function filters give the fastest possible falloff from the band edge to the specified minimum stop-band attenuation for a given number of resonators. Unfortunately, the ITT handbook does not give data to determine element values, partly, I suspect, because too many cases would need to be listed. However, curves are given for the achievable performance of various combinations. Using these as a guide to what is possible, a dedicated experimenter should be able to achieve useful results by trial, at least in a modest case like

four crystals and four adjustable shunt coils. I would start by using the values of coupling capacitors for something like the 1-dB Chebychev case and the corresponding terminating resistance. For this kind of tinkering, one should have a swept oscillator and scope display, preferably logarithmic — equipment unavailable to most of us. Amateurs who work for tax-supported or nonprofit organizations may be able to do some of this tinkering after hours at their places of employment.

other observations

A side issue that needs to be mentioned is the use of extra shunt capacitance across the source or load. These have appeared in some of the references, perhaps by analogy with some image-parameter filter designs. They are essentially unnecessary. They have two effects. First, as with the coupling capacitors in the network, they slightly and insignificantly increase the frequencies of the source and load meshes. Second, they cause the shunt load resistance used on the filter to look like a different resistance in series with the crystal. Recall that the equivalent series resistance is what determined the Q of the end meshes in the design. This parallel to series RC transformation could be part of a matching arrangement, but I would forget it.

summary

Although there has still been some element of trial in the filters constructed, it seems to be mainly attributable to uncertainty in the measurement of the crystal series capacitance. Few trials were needed, generally two, and the terminating resistances and coupling capacitances are theoretically related in a simple way to this one parameter.

The theory reviewed provides a simple, systematic approach to the design of crystal ladder filters. Finally, the use of shunt inductance has been shown to solve the problem of using "unsuitable" crystals and to allow for predetermined nulls in the stop band. These nulls can be used to improve the rolloff at both band edges.

I hope this note will remove some of the mystery from the design of crystal ladder filters and encourage other home brewers to design and build their own.

references

1. Peter J. Hampton, G4ADJ, "Using TTL ICs in the SSB Equipment," *ham radio*, November, 1975.
2. J.A. Hardcastle, G3JIR, "Some Experiments with High-Frequency Ladder Crystal Filters," *QST*, December, 1978.
3. *Reference Data for Radio Engineers*, 4th edition, IT&T Corporation, 1956. More recent editions will also contain the curves and tables required.

ham radio

Auxiliary power system designed for mobile use for the ICOM IC2AT 2-meter handheld transceiver. At right is the homebrew regulator, built around the LM317 IC. Input to the regulator (top) is an accessory plug that connects to a socket beneath the car dashboard (or you could connect it to the car cigar-lighter receptacle). Miniplug on the output end connects to a BP4 battery case, which contains six rechargeable nicads. The small addition on the bottom of the BP4 battery case is described in the text. Note the hole in the leather carrying case, which was made for the external power plug.

two-way power for the IC2AT 2-meter handheld

Running out of battery power on the freeway? Here's a neat solution using a homebrew regulator

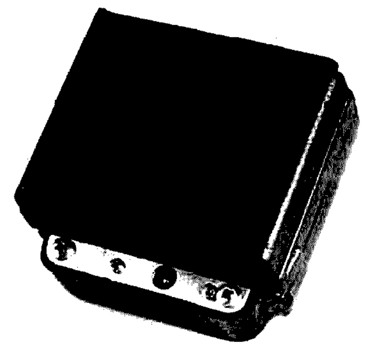
I was in rush-hour traffic on the interstate, with one hand on the steering wheel and the other holding my new ICOM IC2AT transceiver, when suddenly the transmit-indicator light went out, indicating that my nicads had run down. What to do? Try to remove the radio from its leather case and change battery packs while driving? Impossible! Pull off the road and change batteries? Too much traffic! Only one choice left — I made a quick apology to the people with whom I was in contact and shut down.

This situation occurred two days after I had purchased my IC2AT, and it made me realize that 40 minutes of rag chewing twice a day during my drive to and from the office was just too much for my nicads to take. I immediately began thinking of a better way to enjoy the versatility of this neat little 2-meter rig.

about the IC2AT

The IC2AT hand held has become an instant success with Amateurs in my area. With its compact size, high-quality construction, excellent operating reports, and low price it's hard to beat. I bought one with the objective of having a pocket-size 2-meter rig that I could use in my car while commuting to work; from my desk in my office as well as on my boat; at hamfests; and on occasional business trips to other areas of the country.

By Gil Weiss, WB3JJF, 3004 Hallowell Court, Bensalem, Pennsylvania 19020



Rear view of the modified BP4 battery pack showing charger jack.

A spare battery pack was required, and I decided on the BP4 battery case, which I loaded with six AA-size rechargeable nicads. This spare power pack lasts much longer than the standard 250-milliampere-hour battery that comes with the rig. The power output of the radio is slightly lower, however, because of lower voltage from the six 1.25-volt nicads. But even armed with two batteries, I still had mobile power problems, because I couldn't remove the unit from its protective leather case and change power sources while driving.

operating problems

Purchasing the dc regulator offered by ICOM appeared to be the solution to my problem. The regulator is built into a slide-on battery case and decreases the 13.8-volt auto voltage to the required 8.4 volts specified in the ICOM instruction manual. But — and there always seems to be a *but* or *however*, as nobody seems to make the perfect rig or accessory — the jack that's used to plug the regulator base into the auto electrical system is located on the back of the unit, directly behind one of the big metal snaps on the rear of the leather case.

Even if you drill out the snap (which would not do your case much good) or used the rig out of the case, laying it on your car seat or hanging it on your dashboard, you still have the problem of the plug and wire coming out of the rear of the radio. When I got to work I'd have to remove the unit from the leather case, take off the regulator, put on a battery pack, replace the unit in the case — and then repeat the entire procedure when leaving work for home. A better solution was needed.

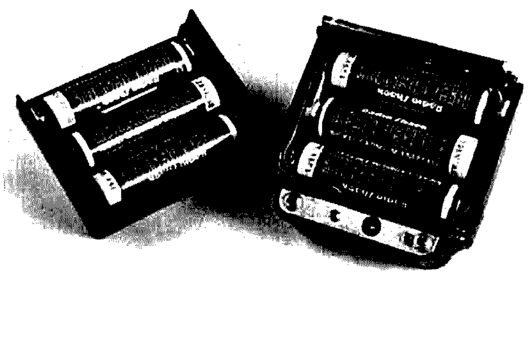
the two-way supply

The product of my imagination is shown in the photos. I built a voltage regulator circuit using an LM317T variable-regulator chip in a case measuring 3-1/4 x 2-1/8 x 1-1/8 inches (8.3 x 5.4 x 2.9 cm). One end plugs into the auto electrical system either through the cigar lighter or, as in my case, through an accessory plug wired under my dashboard. The wire from the output end terminates in an 1/8-inch (3-mm) miniplug, which goes to the main part of my invention — a BP4 battery case which holds six AA nicads and which has a small addition on its base that accepts the external power plug from the regulator.

When you plug in the regulator the normally closed miniplug jack disconnects the internal batteries, and when you remove the miniplug, the batteries are once again connected and ready to provide portable power. The leather case is included in the photo to show where I made the hole for the external power plug on the lower front of the radio.

For added convenience, a charger jack is also built into the battery case addition, which allows using the BCU-25 wall charger that comes with the radio or any other 10-15-volt 50-mA dc converter/charger. You don't need to use the ICOM drop-in quick charger for the BP4 pack, as stated in the IC2AT manual.

Another photo shows the rear of the modified BP4 pack, which includes the charger jack. The addition to the battery pack case was cut from a small box, just like that used for the regulator circuit. I cut and epoxied it to one side of the BP4 pack so the case could be opened and closed to install or remove batteries. This piece of the box contains a normally closed miniplug jack, which does the switching from internal to external power, plus a coaxial charging jack.



Interior of the battery case with nicads installed.

Those who complete this easy project will be rewarded with a great little 2-meter rig which, after operating indefinitely from your auto electrical system, can be quickly removed by disconnecting your mobile antenna and unplugging your external voltage regulator. Just put your rubber duck back on and you're instantly ready to operate portable. All this can be done while keeping your radio safe in its leather case. Additionally, with your dc regulator you can run the rig from your home on any 12-volt power supply, or an old auto battery, which could provide communications capability during power outages.

construction

The regulator schematic is shown in **fig. 1**. I built the circuit on a piece of perf board cut to fit inside the box. The regulator chip and heat sink were placed on the bottom side of the board; all other components were placed on top. (All components are available at Radio Shack stores except for the 12-volt, 5-watt zener, which was included for over-voltage protection of the rig.) If a spike greater than 12 volts should occur, the zener will shunt the circuit to ground and blow the fuse.

A subminiature slide switch and a green LED were also included, since the regulator should always be turned off when inserting the output plug into the rig. (These plugs easily short out for an instant while being plugged in or out of their jack.) Wire the tip of the miniplug for 8.4 volts, and upon completion of the regulator circuit, adjust the 5k variable resistor for 8.4 volts output before installing the top of the box.

Fig. 2 shows the parts layout and wiring diagram for the battery case addition. Unsolder the orange (battery positive) wire inside the BP4 case from the positive connection at the top of the case and reroute it into the addition. Connect it to the enclosed jack.

Wire routing is done through two holes drilled in the two square indentations on the bottom of the BP4 case. A new wire goes from the positive side of the enclosed miniplug jack to the slide on the connector at the top of the battery case, where the orange lead was disconnected. Route another wire connecting the negative terminal on the miniplug jack and the negative side of the charging jack to the negative connection inside the BP4 case. Wire the charging jack in parallel with the battery circuit as shown. This completes all electrical work.

The mechanical part starts with cutting off a portion of the second box to the dimensions shown in **fig. 3**. The inside space must be just deep enough to fully enclose the miniplug jack. You can't make this addition too deep, or the whole unit won't fit into the leather case. I used a fine hacksaw and carefully sanded the piece of box to final dimensions with No. 400 silicon paper.

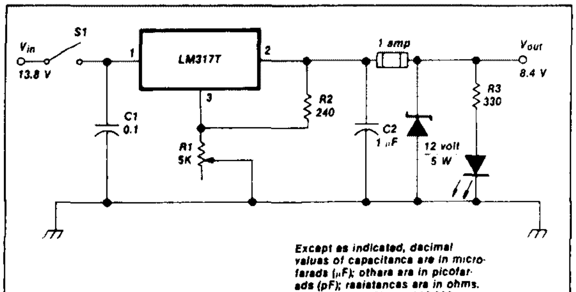


fig. 1. Schematic diagram of the regulator circuit. Zener provides protection against voltage spikes.

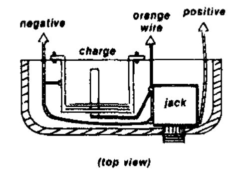


fig. 2. Parts layout and wiring for the battery-case addition.

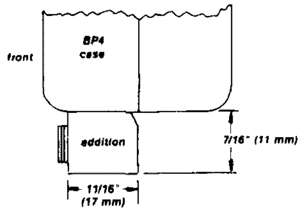


fig. 3. Surgery necessary to include the additional box to the BP4 case. See text for correct method of adding this unit.

Some interior trimming with a knife was necessary to make room for the wires. The charging jack also required some filing to fit properly. I also lightly sanded the entire bottom of the case to ensure a good bond with the epoxy, which will hold things permanently in place. Either the quick-setting (5-minute) or regular resin/hardener epoxy may be used for this job.

The metal side of the addition was carefully drilled to fit the charging jack, and the edge was beveled with the silicon paper on a block so that the case could easily be opened and closed.

A little patience and care with your saw, file, and abrasive paper will produce a result that will greatly add to the operating convenience of the IC2AT.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

One of the interesting challenges of writing a monthly column is that you "write behind" the publication date by about three months. That is, this piece will appear in the February, 1982, issue of *ham radio*, but it is being written the first weeks of October, 1981. As of this writing, the future of the new "30 meter" Amateur band (10.1 to 10.15 MHz) is somewhat uncertain. Assigned at the World Administrative Conference of 1979 to the Amateur service on a secondary basis, this band could possibly be open to Amateurs worldwide by January 1, 1982. Indeed some countries have already announced the band as open to hams as of that date.

The situation is a little more complex in the United States, as the Senate has not yet ratified the treaty containing the provisions for the new band. And no one knows what the FCC has in mind for the band so far as Amateur occupancy goes. The latest scuttlebutt I hear is that a decision will be made in "early spring, 1982." That assumes, of course, that no hang-ups pop up along the way.

In any event, the band is in the offing and many Amateurs are wondering if their equipment will work on the new band and what problems, if any, they may encounter in firing up on the new frequencies.

Some of the more modern exciters have a bandswitch position for 30 meters and many older pieces of equipment (such as the Collins S-line and the Drake T4-R4 combos) provide tuning information and crystal data for the 10-MHz band. Thus many hams are all ready to go now, and others with older gear can be on the band by buying a new conversion crystal or two and retuning their equipment as outlined in the instruction manual.

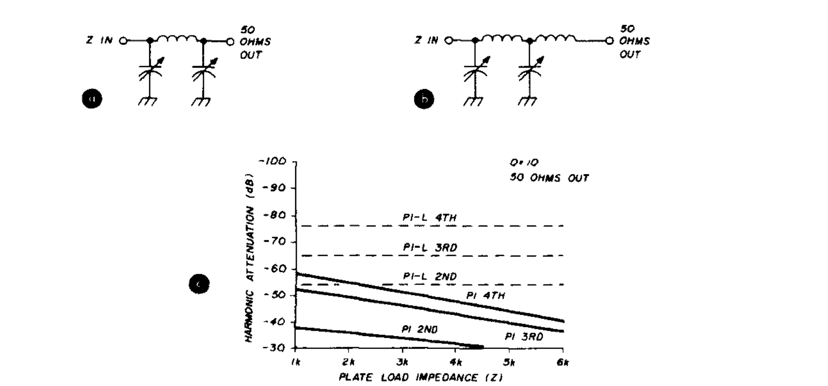
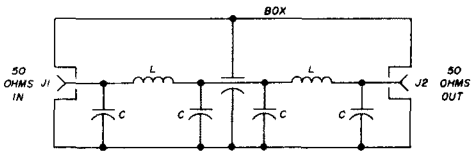


fig. 1. (A) Conventional pi network output circuit; (B) improved pi-L output circuit; (C) attenuation curves for pi and pi-L networks as a function of plate load impedance.

watch out for transmitter harmonics

Remember that the harmonics of a 10-MHz signal do not fall in any



band	C	L
160	1700 pF	4.2 μH. 22 turns No. 16 (1.3 mm) AWG solid, 1" dia. × 2" long (2.5 × 5 cm)
80	850 pF	2.1 μH. 13 turns No. 16 (1.3 mm) AWG solid, 1" dia. × 1-3/4" long (2.5 × 4.4 cm)
40	440 pF	1.1 μH. 8 turns No. 16 (1.3 mm) AWG solid, 1" dia. × 1" long (2.5 × 2.5 cm)
30	330 pF	0.8 μH. 9 turns No. 16 (1.3 mm) AWG solid, 3/4" dia. × 1" long (1.9 × 2.5 cm)
20	220 pF	0.55 μH. 7 turns No. 16 (1.3 mm) AWG solid, 3/4" × 7/8" long (1.9 × 2.2 cm)
15	160 pF	0.41 μH. 8 turns No. 16 (1.3 mm) AWG solid, 1/2" dia. × 1" long (1.3 × 2.5 cm)
10	110 pF	0.3 μH. 6 turns No. 16 (1.3 mm) AWG solid, 1/4" dia. x 3/4" long (0.6 x 1.9 cm)

fig. 2. Design data for half-wave filter.

Amateur band. The burden of harmonic suppression to protect other services falls upon the Amateur operator.

Unfortunately, most commercial Amateur transmitters employ a simple pi-network output circuit, or a broad-band coupling transformer (in the case of a solid-state rig). The harmonic rejection of these circuits is marginal at best and can be insufficient to suppress bothersome harmonics that might interfere with services in the 20-MHz region. Particularly in the case of the tube-style transmitters with pi-network output circuit, although they can be retuned quickly to the 10-MHz band their pi-network design is optimized for operation in the nearby Amateur band. Retuning the network to the new band, even though the instruction manual tells the operator how to do it, may mean that the suppression ability of the network is seriously impaired.

As an example, suppose you have a transmitter that you are retuning from 7 MHz to 10 MHz (a common case). According to the manual, the bandswitch is left on the 7-MHz (40-meter) position, but the controls are tuned to new reference points for 10 MHz as given in the manual. You are now on 10 MHz! But what happened to the harmonic suppression of the output circuit? The manual doesn't say.

Harmonic suppression ability of pi and pi-L networks is illustrated in **fig. 1**. Let's compare the harmonic suppression of the two configurations. Take the case of a pair of 6146s operating at a plate potential of 800 volts and a peak plate current of 220 mA. The approximate plate load impedance in this case is about 2140 ohms. Second harmonic rejection with the conventional pi-network is about −35 dB, and third harmonic rejection is about −47 dB. This marginally meets FCC requirements for good engineering practice.

Now note that under the same operating conditions, second harmonic rejection by the pi-L network is about −52 dB and third-harmonic rejection is about −65 dB. A great improvement!

But how many Amateur exciters or transceivers make use of a pi-L output network? I'm afraid that most Amateur equipment designs are straight out of the Stone Age in this respect. A pity, since factory conversion to a pi-L design is inexpensive and nearly 20 dB of extra harmonic rejection can be had for pennies.

And the harmonic problem can grow worse when the exciter is hooked to a linear amplifier. Have you ever heard the harmonic of a SSB signal? It is the darndest sounding, Donald-Duck-type of gabble. But enough intelligence exists in the speech for a sharp-eared FCC monitoring station to establish your call letters.

simple add-on harmonic-suppression circuit

There's no need to revamp your station equipment to reduce transmitter harmonics to a reasonable level. You can add a high-frequency harmonic filter between the equipment and the antenna. The half-wave filter design shown in **fig. 2** will do the job.

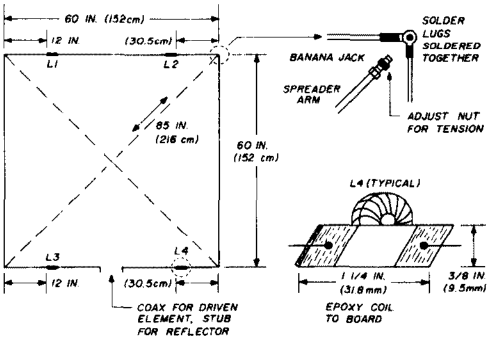


fig. 3. Mini-quad assembly. Mini-quad loop is 60 inches (152 cm) on a side for each element. Coils are placed 12 inches (30.5 cm) from the ends of the horizontal wires. For center frequency of 28.6, L1 or L2 are 20 turns, L3 and L4 are 22 turns. Use No. 22 enamel wire on T-50-6 Amidon form (yellow). Iron-powder core is 0.5 inch (12.7 mm) outside diameter, 0.303 inch (7.7 mm) inside diameter, permeability 8. For 29.6 MHz, L1 and L2 have 19 turns, L3 and L4 have 21 turns. Driven element to reflector spacing is 50 inches (127 cm). See photos for assembly details.

fig. 4. Wood boom has PVC plastic pipe union driven on it and screwed in position. The plug of the cross-arm support slips into open end of the union. Boom is coated with varnish after completion to prevent the wood from warping.

This unit has a cut-off frequency somewhat above the band in use; it provides about 30 dB attenuation to the second harmonic of the transmitter and approximately 48 dB attenuation to the third harmonic. Component values are given for all high frequency Amateur bands, but the one of greatest interest at the moment is the model for the 10-MHz band. Only four capacitors and two air-wound inductors are needed. Maximum harmonic attenuation is achieved when the filter is built in a shielded box with two compartments. One section of the filter is placed in each compartment, as shown in **fig. 2**.

building the filter

A variety of aluminum boxes can be used for the filter. I suggest either the BUD "Minibox" or "Utility Cabinet." The size of the box depends upon the size of the components. For transmitters and receivers up to 100 watts output or so, I suggest 500-volt, dipped-mica capacitors, such as the Cornell-Dubilier CD series. Silver-mica capacitors of 1-kV "postage stamp" variety are also acceptable. For higher power levels, transmitting-type mica capacitors of 2.5 kV to 5 kV are suggested. (The voltage rating of the capacitor is not the limiting factor; it's the current-carrying ability. Roughly speaking, this is a function of the area of the capacitor plates. Physically small mica capacitors, while they might have a satisfactory voltage rating, usually cannot stand the rf current).

The inductors can be portions of miniature manufactured coils, such as the so-called "miniductors" made by several manufacturers. Or they may be self-supporting and made of heavy copper wire. The shield should be firmly bolted to all sides of the box. Coaxial receptacles are placed on the ends of the enclosure.

When completed, the filter can be adjusted by soldering a low-inductance ground strap to the lead between the two inductors where it passes through the hole in the shield. When this point is grounded, each coil and capacitor configuration may be dipped to resonance at the design frequency. All that is required is a slight adjustment of the coil turns. Once this is accomplished the box is sealed up.

using the harmonic filter

The filter is placed in the 50-ohm coaxial line between the antenna and station equipment. If an SWR meter is used, it should be placed between the filter and the transmitter. You don't want anything after the filter that might upset the filter's excellent harmonic rejection ability.

Remember, the filter rejects signals above its design frequency. It cannot be used on a higher frequency band. Essentially, it is a one band affair, and using it on a higher band will probably damage the capacitors.

the WØJZY mini-quad for 10 meters

The ham world abounds with mini-antennas and some of them work. Unfortunately most of them don't, so it is refreshing to find a mini-quad that delivers the goods. It was developed in 1978 by Leo Parra, WØJZY. I've heard him using this little antenna on 29.6 fm for several years, and his signal is outstanding. So I prevailed upon Leo to send me the information. Here's the story of his mini-quad antenna.

Electrically, the antenna is a loaded quad with a driven element and reflector (**fig. 3**). Four small toroids are placed in each loop, and these loading coils reduce the quad to about five feet on a side. Spacing between elements is 50 inches (127 cm).

The quad's driven element is fed at the center of the bottom wire with RG-58/U coaxial line. When fed directly, the radiation pattern is not quite symmetrical about the boom axis. The purist can place a balun at the feed point and re-establish pattern balance.

The front-to-back ratio is established with a short stub on the reflector element. A section of 300-ohm TV "ribbon" line is used, with the open

ends shorted together. The stub is about 16 inches (40 cm) long to start with and it can be adjusted at the design frequency by listening to a local station off the back of the antenna and progressively shortening the stub by moving the short along the line toward the antenna. This can be done by gently seizing the stub with a pair of wire cutters and squeezing the cutters until they "nick" both wires of the line. If you inadvertently cut the line, it is no great loss and another one can be quickly substituted.

To get the antenna "in the ballpark," each element is dipped individually before assembly. The driven element is dipped about 400 kHz higher than the design frequency, and the reflector is dipped about 200 kHz lower than the design frequency. The loops are then assembled to the boom. For example, assume the antenna design frequency is 28.6 MHz. The driven element is dipped to 29 MHz (a one-turn loop placed across the loop's coaxial cable terminals will provide good coupling). The resonant frequency can be moved about by squeezing the turns equally on the loading coils or by adding or subtracting an inch or two of wire equally on each side of the quad loop.

The reflector is now dipped at 28.4 MHz. A small one-turn loop placed at the far end of the stub will do the job. Trim the stub length until you are on the nose. You can make a final check with a local signal on front-to-back ratio and you may not have to make any further adjustments.

Leo makes his adjustments with the loops in a vertical plane and with at least five feet clearance above ground to the bottom wire. A stepladder will do the job.

building the mini-quad

There are many ways of making the little quad. Leo uses a boom made of well-seasoned wood (Perhaps a closet pole? I didn't ask him what the wood was.) It is small enough in diameter to fit with a PVC pipe union, two of which are force-fitted onto the pole ends, (**fig. 4**). The union is for 3/4-inch water pipe. A short plug fits into the open end of the union and the quad arm supports are bolted to the plug. Each quad arm is made of a length of fiberglass rod, which looks suspiciously like a section of a fishing pole. They are very light and flexible. A banana jack is force-fitted on the end of each pole. The poles join at the center in an X-fitting (**fig. 5**) made of short sections of angle stock bolted together to form a hollow cross. The cross support, in turn, is bolted to the plug.

Leo's loops are made of insulated, flexible, test lead wire. Each quad loop is assembled with the loading coils and, at the points where the loop meets the fiberglass rods, the wire is broken and two large soldering lugs are soldered together and slipped over the banana jack's threaded shaft. A nut on the shaft is adjusted for tension. The wires are soldered to the lugs (**fig. 6**).

Before assembly, the whole mess has the rigidity of a wet noodle. But wait! Leo assembles the loops flat (on a picnic table, for example). He pushes the cross-shaped center spider onto each end of the boom, then pushes the fiberglass arms into the open ends of the spider. He then stretches the loops out, snaps the soldering lug assemblies over the ends of the banana jacks and tightens the tension bolts. With a little persuasion, the quad loop becomes amazingly rigid. The loops are then attached to the boom, the feedline (and balun, if used) attached to the driven loop, and the coax is brought back to the boom and taped along it.

When I assembled my W0JZY quad I used two eight-foot sections of a TV mast to support it about 15 feet (4.6 meters) in the air. The mast was held in a vertical position by placing it in a concrete base intended to hold a beach umbrella.

Sure enough, the little quad worked. Without any adjustment other

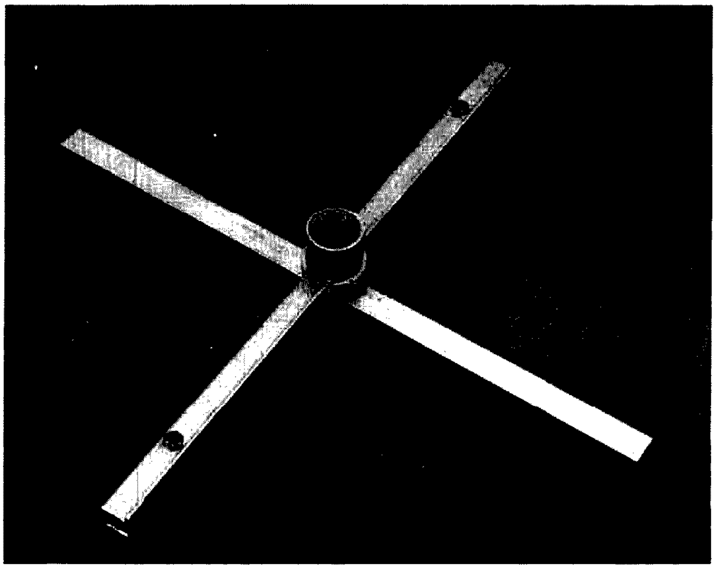


fig. 5. Quad cross-arm support is made of aluminum angle stock bolted together to form a square, hollow tube. Two tubes are mounted to plastic plug which slip fits within union attached to end of the boom. Fiber glass rods slip into ends of the X-fitting.

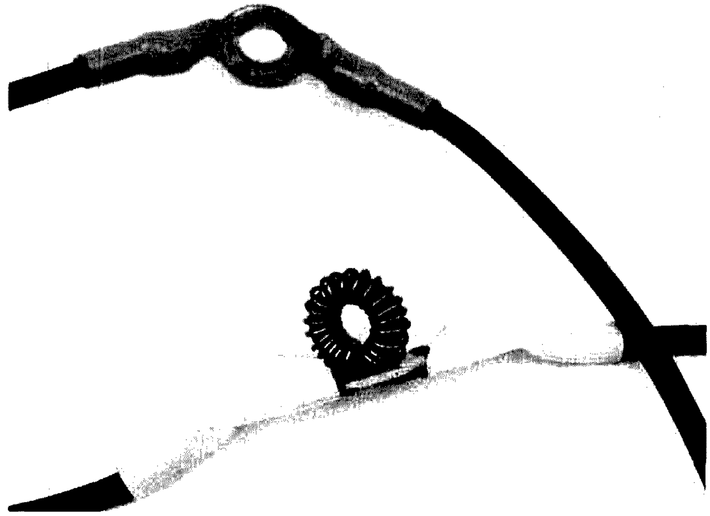


fig. 6. Close-up of the toroid coil and the double solder lugs. The powdered-iron coil is epoxied to a miniature insulator made of a scrap of printed circuit board. Antenna wires are soldered to ends of the board and heat-shrink tubing placed over the connections. Soldering lugs are sweated together to form a double-ended fixture which slips over the barrel of the inverted banana jack driven onto the tip end of the fiber glass support arm. Flexible, insulated test lead wire is used for element loops.

than dipping the elements, the quad exhibited about 10 dB front-to-back ratio at the design frequency. As for the gain — who can tell? Leo's signal with his mini-quad is excellent, and I worked many stations with this little antenna. In truth, it was not as good as my four-element Yagi atop a fifty-five-foot tower, but that is comparing apples and oranges. I'll tell you this — it was a *lot* better than a ground-plane antenna erected in the same place and at the same height.

I haven't given specific build-it-yourself dimensions but you should be able to construct your own mini-quad from this data. Leo had problems mounting the toroid coils in the antenna wire, but finally made up a small insulator out of dual-sided printed circuit board. He fastened the toroid to the board with epoxy cement and trimmed the copper face out at the center to form a simple insulated mounting. Each end of the winding, plus an antenna wire, was soldered to each end of the home-made insulator. I'm sure you can think of other means if you put your mind to it.

When properly made, the mini-quad can be erected or taken down in a few minutes. It makes an excellent antenna for Field Day, in addition to being an all-around good beam for those Amateurs who have restricted antenna space. No doubt the mini-quad can be modified for other ham bands. I'll leave that design modification up to you!

Note: For more information on quad antennas, refer to "All About Cubical Quad Antennas" by W6SAI and W2LX, available from Ham Radio's Bookstore.

ham radio

an armstrong beam rotator

In the early days of Amateur Radio, when beam antennas were somewhat of a novelty, the *Radio Handbook*[1] published a method showing how to turn the beam from inside your station. It was a good idea, but required a hole in the roof to accommodate the antenna mast. This requirement could pose all sorts of problems, depending on your roof structure and antenna-control position. (The device was directly beneath the antenna mast.) Other problems come to mind: what do you do if the rotor motor freezes after the warranty runs out? How do you seal the hole for the mast if you have a shingle roof?

Here's an alternative beam rotator that requires no electrical power, doesn't freeze, needs no long control cable, and needs no electrically driven direction indicator. All you need is some muscle power and a little ingenuity. And that's what ham radio is all about!

thrust bearing

Beam antennas that don't need a tower can be rotated by putting one end of the vertical support (pole or pipe) into a thrust bearing at ground level. (I chopped a round hole into my concrete patio, using a hammer and chisel.) You can also use ball bearings or something else more exotic. Or, a pipe flange slightly larger than the support pipe can be secured

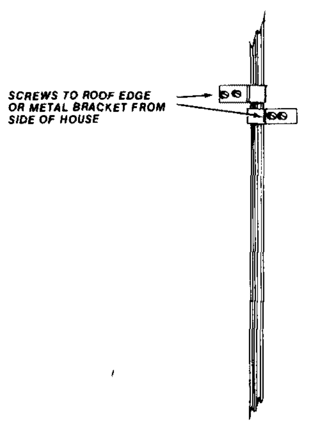


fig. 1. Antenna mast supports consist of pipe clamps secured to the edge of the roof or to a metal bracket mounted to the side of the house. Mast must be plumbed vertically and rotate freely inside the clamps.

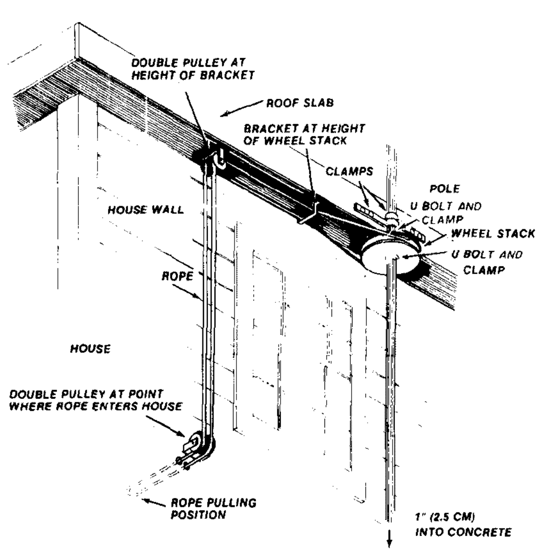


fig. 2. Suggested mounting arrangement for mast and drive wheel.

onto a greased platform mounted on the ground. Let your imagination run free!

mast support

The thrust bearing support for the pole should be located by a plumb bob held from the next higher, or final, support for the pole, which is often at the edge of your roof. My roof consists of a flat concrete slab which extends a couple of feet further out than the house. If you have a Cape Cod or similar roof, you'll have to mount a bracket secured to the side of the house, with clamps attached to the bracket where the pole just misses the edge of your roof. One pipe clamp facing one direction and another clamp facing the other will do nicely (**fig. 1**).

Secure the pipe clamps with bolts or screws at the plumb-bob point so that the pole is held vertically but can be rotated in the clamps and thrust bearing a full 360 degrees.

Allow enough space between the pole and the side of your house to accommodate the radius of the

By John R. Schuler, KP4DM, Ruta Rural Buzon 2593A, Vega Baja, Puerto Rico 00763

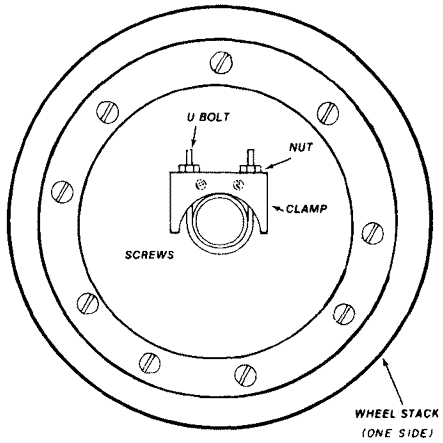


fig. 3. Detail showing method of securing wheel stack to the mast (one side only shown).

wheel-like device, which will allow you to rotate the antenna mast by means of a nylon rope and your arm muscles. Before you position either the thrust bearing or the pipe brackets with their supports, consider the radius of this wheel, keeping in mind the pole as the axis of the wheel. The wheel must be able to turn without scraping the side of your house. **Fig. 2** shows a suggested mounting scheme.

drive wheel

Recall the grooved wheel often found in dial-drive mechanisms. Cords are fastened to the wheel with springs in counter directions, so that pulling on one cord rotates the wheel one way, and pulling on the other cord rotates the wheel the other way. For my wheel, I used both ends of a wooden wire reel after removing the spindle between the ends. The hole in the center of each end piece is for supporting the pieces on a tube so that the wire may be unloaded by revolving the wheel. The hole should be big enough so that your pole mast can pass through it.

After the removal of the screws that hold the reel together, the spindle may be removed and discarded. You can probably find such a reel at a hardware store, the telephone company, power company, or an electrical contractor.

wheel assembly

Place both wheels over your pole and secure them together in several places with bolts and nuts. Holes for the bolts should be drilled about 1 inch (2.5 cm) in from the perimeter of the wheel. You now have a two-wheel stack. Next, get some sheet metal and cut pieces so that they may be secured with other bolts and nuts to the top and bottom of the two-wheel stack to form lips that extend the wheel perimeters about 2 inches. You have now made a channel for supporting the turning ropes so that they don't fall off the wheel (and are not pulled off when a little slack works into either rope).

The next step is to attach some U bolts and clamps to the top and bottom of the wheel stack with screws so that the wheel stack is held horizontally in place when you tighten the nuts of the U bolts (after placing stack over the pole.) See **fig. 3**.

Now decide where to place the double pulleys so that the end of the rope arrives inside the room at a convenient place. Add a few more feet of rope to allow yourself pulling room, a place to clamp the ropes when the beam points where you want, and a few more feet to cover the wheel stack perimeter.

dressing the pull rope

Purchase double this length of 1/4-inch nylon rope. Secure one end of this rope to the wheel stack perimeter and rotate the wheel more than 360 degrees either clockwise or counter clockwise. Pass the other end of the rope through the pulley sets, into and out of your shack, back through the pulley sets, and back to the wheel stack.

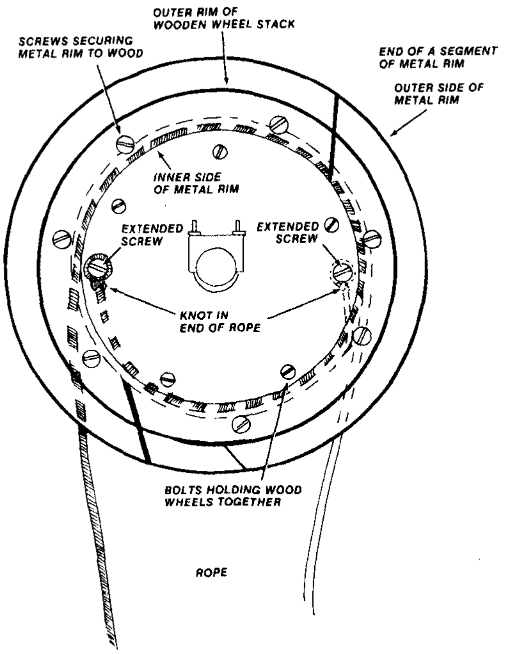


fig. 4. Method of dressing the pull rope around the wheel stack. A sheet metal extension around the periphery of the wheel provides a lip or trough for the pull rope.

Rotate the wheel stack in the opposite direction, keeping the rope you first secured taut, and place the end of the rope at a point again more than 360 degrees and again secure it near the perimeter. Now, by pulling on the first rope the wheel stack will rotate in one direction and by pulling on the other rope, the wheel stack will rotate in the other direction. The complete assembly of the wheel is shown in **fig. 4**. You are now ready to mount your Yagi to the pole and keeping the ropes taut, rotate your beam from the shack.

final touches

Final niceties include a) mounting a microphone holder to grip the rope in a taut position inside the station, b) painting the wheel stack, and c) marking the rope with compass directions. I applied paper labels marked with compass directions to the rope using Scotch™ tape so that, with everything taut, the marker at the bottom of the U-shaped rope facing the operator shows the direction in which the beam is pointed.

In my installation, a coat-hanger wire makes a support channel for the ropes where the distance between the pulleys and the wheel would otherwise allow the ropes to sag into a spot where they could snag the back door. It's best to lay out the whole arrangement in advance to avoid more pulleys and direction changes than are absolutely necessary. Naturally the more pulleys and direction changes, the more force needed to pull the beam to a new direction. Also don't forget that inertia and momentum play a part. It takes a strong pull maintained for a few seconds before the beam starts to turn and less to keep it turning. Additionally, ease up on the pulling as you near the direction you want, otherwise you will overshoot the direction.

At my house I have only two double pulleys and the coat hanger before the rope arrives at the wheel. Don't forget that you'll have to drill two holes through your window or house wall to allow the rope to enter and leave the pulling area. Keep the holes in line with the location of the last pulley to reduce frictional losses.

If you get a larger-diameter wheel stack, the rope will be easier to pull against frictional losses but a longer rope and a longer pull distance will be required because of the increased circumference. Also, the center hole may have to be much larger diameter than desired. A bicycle wheel rim could be used but might present more problems.

reference

1. *Radio Handbook*, Editors and Engineers Division, Howard W. Sams & Co., Inc., 1951 edition.

ham radio

short circuits

biquad bandpass filter

Author NØDE has written to point out that the two values of C in the biquad bandpass filter (June issue, **fig. 1**, page 70) should be equal for **eq. 1** to be correct. In **fig. 1** both values of C should be 0.1 μF. Also, placement of the left-hand IC on the PC board (**fig. 2**) is reversed; the notch should be oriented toward the lower edge of the circuit board.

updating the HW-2036

Complete circuit board layouts for WA4BZP's article (November, 1980, *ham radio*) are available by sending a stamped, self-addressed envelope to *ham radio*, Greenville, NH 03048.

quad variations

There is a drafting error in **fig. 4** of the ham notebook item "More Quad Variations" published in the October, 1980, issue of *ham radio*. The right-hand apex of the figure should be open; otherwise, the antenna will not resonate.

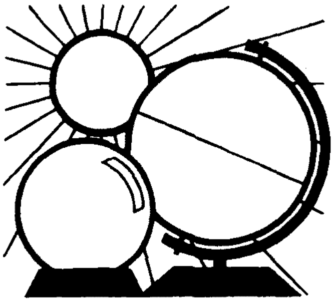
CW identifier

The following corrections should be incorporated in the article "Versatile CW Identifier," which appeared in the October, 1980, issue of *ham radio*: R2 is a 1-megohm pot. Pin 11 of U2 is listed twice; ignore the one that is grounded. R3 and C2 should be interchanged. In all cases, the PC board layout is correct as published.

antenna match

There are two errors in the article by Leonard H. Anderson that appeared in the January, 1981, issue of *ham radio*. In the right-hand column of page 59, the second line from the top of the page should read as follows: $= 153.04 \,/\, 3.9 = 39.24$ *feet*. **Equation 3**, in the same column, should read as follows:

$$\beta = arctan \frac{R_O(R_O - R_L)}{R_O X_L + R_L X} \qquad (3)$$



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

Excellent conditions are forecast for the first and last weeks of February, with a dip of fair-to-good conditions in between. The excellent conditions should mean the higher frequency bands for long-haul DX can be counted on for some really good DX sessions. In between, in mid-month, the lower bands will be open for some all-night DX activity, if you're game. Some disturbed periods can be expected at that time about the 8th, 16th, and 25th. These periods should keep all of the bands interesting. Look for that intriguing new DX contact you haven't yet heard.

February propagation events

If you have fast mail service and live in New Zealand (South Island) or elsewhere in the South Pacific, the tip of South America, or the South Atlantic or Indian Ocean areas, you may be interested in this notice of a middle-size partial eclipse of the sun on January 25th from 0250 to 0634 UT. We will have to wait until June and July for any other eclipses this year. The moon will be full on the 8th.

No significant meteor showers appear in February. February, however, is often the month with the highest mean solar radio flux values this year. This is a result of the Earth's being closer to the sun during these winter months. The higher average radiation into the ionosphere from this 5 percent decrease in distance is significant. There is, however, an ionization build-up lag, so that February is often the high.

The winter months are also the most free from geomagnetic disturbances, which tend to lower the mid-latitude maximum usable frequencies (MUFs). Two factors are therefore working together to produce high MUFs in winter. In some years, though, the equinox periods, which provide favorable partial path alignment to the Earth, build high MUFs from solar flare activity at equinox. In these years the equinox periods might outdo the winter for the highest solar flux values. In either case the result is the highest daytime high frequency and VHF DX paths of the year. Geomagnetic activity pushes the ions toward the geomagnetic equator in Peru. The one-long-hop transequatorial propagation path results from refraction from the ionization maximums on each side of the geomagnetic equator and not reflecting from the Earth in between. Look for it in the late evening.

February is the month when changes in the ionosphere portend leaving the winter DX conditions of November, December, and January behind. The 10, 15, and 20 meter bands can be expected to open sooner in the morning and stay open longer into the evening. On the 40, 80, and 160 meter bands, which depend on darkness for their openings, the DX hours can be expected to shrink.

band-by-band summary

Six meters will open occasionally toward Europe — that is, to the east before noon, toward the south during noontime to afternoon, and toward the west and northwest in the late afternoon into early evening. The best openings are most likely transequatorial during high solar radio flux in evenings.

Ten and fifteen meters will exhibit the same pattern as 6 meters but will be open a longer part of the day. This is particularly true this month, since it is nearing springtime with its noticeably longer days and probably higher MUFs because of higher solar flux.

Twenty meters is a great band for everyone's pleasure, limited only by QRM. It should be open nearly every day and late into each evening to almost every part of the world. Best DX conditions can be expected just after sunrise and just before sunset for long skip.

Forty meters begins a transition into a nighttime band. Short skip during the daytime in winter, however, gives some interesting opportunities for working your close neighbors for the WAS certificate. Then, at evening, as the long skip (1000 to 2500 miles) develops, reach out for the far states and the WAC certificate. This band is very active to most areas of the world. In late afternoon the band will open to Europe, then swing around to South Africa and Central and South America, and then swing still farther into the Pacific by dawn.

Eighty and one-sixty meter DX conditions will be very good this month. Soon the atmospheric noise of the spring storms will give days of short skip QRN and local QRN. On toward summer the static will become bad enough that DX will have to be forgotten until fall. Take advantage of what's left of this year's quiet winter season. The directional pattern for these bands is similar to that of 40 meters. The low take-off angle of vertical antennas is very useful for DX here. Horizontal antennas are mainly short skip, high-take-off-angle radiators because of being so close to the ground. Look for particularly interesting DX as these bands come in (open) near sunset and go out at sunrise.

ham radio

WESTERN USA

FEBRUARY

GMT	PST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	4:00	10	—	15	10	15	10	10	10
0100	5:00	10	—	15	10	15	10	10	10
0200	6:00	10	—	15	10	15	10	10	10
0300	7:00	10	—	20	15	15	10	10	15
0400	8:00	15	40	20	15	15	10	15	15
0500	9:00	15	40	20	20	15	15	15	15
0600	10:00	20	40	20	20	15	15	15	20
0700	11:00	20	40	20	20	20	20	20	20
0800	12:00	—	20	20	20	20	20	20	20
0900	1:00	—	20	—	20	20	20	20	40
1000	2:00	—	20	—	20	20	20	20	40
1100	3:00	—	20	—	20	40	40	20	20
1200	4:00	—	—	—	20	40	40	40	40
1300	5:00	—	—	—	40	40	40	40	40
1400	6:00	—	—	15	40	40	40	40	40
1500	7:00	—	15	10	20	80	20	20	40
1600	8:00	20	10	10	10	—	15	20	20
1700	9:00	20	10	10	10	—	15	20	20
1800	10:00	20	10	10	10	—	10	15	20
1900	11:00	20	15	10	10	—	10	15	—
2000	12:00	20	20	10	10	—	10	10	—
2100	1:00	15	20	10	10	—	10	10	15
2200	2:00	15	20	10	10	—	10	10	10
2300	3:00	10	20	10	10	—	10	10	10

MID USA

GMT	MST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN	CST
0000	5:00	10	20	15	10	15	10	10	10	6:00
0100	6:00	10	20	15	10	15	10	10	10	7:00
0200	7:00	10	20	20	15	15	10	10	10	8:00
0300	8:00	10	40	20	15	20	10	10	15	9:00
0400	9:00	15	40	20	20*	20	15*	15	15	10:00
0500	10:00	15	40	20	20	20	15	20	20	11:00
0600	11:00	20	40	20	20	20	15	20	20	12:00
0700	12:00	20	40	—	20	20	15	20	20	1:00
0800	1:00	—	—	—	20	20	20	20	20	2:00
0900	2:00	—	—	—	20	20	20	40	20	3:00
1000	3:00	—	—	—	20	40	20	40	—	4:00
1100	4:00	—	—	—	40	40	20	40	—	5:00
1200	5:00	—	—	—	40	40	20	40	—	6:00
1300	6:00	—	20	—	20	40	20	40	—	7:00
1400	7:00	—	15	20	15	—	20	20	—	8:00
1500	8:00	—	10	10	10	—	20	20	20	9:00
1600	9:00	—	10	10	10	—	15	15	20	10:00
1700	10:00	20	10	10	10	—	15	15	20	11:00
1800	11:00	20	15	10	10	—	10	15	—	12:00
1900	12:00	20	15	10	10	—	10	15	—	1:00
2000	1:00	20	15	10	10	—	10	10	—	2:00
2100	2:00	20	20	10	10	—	10	10	20	3:00
2200	3:00	15	20	15	10	—	10	10	10	4:00
2300	4:00	10	20	15	10	15	10	10	10	5:00

EASTERN USA

GMT	EST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE CARIBBEAN S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	7:00	15	20	15	10	15	10	10	15
0100	8:00	15	20	15	10	20	10	10	15
0200	9:00	15	20	20	15	20	15	15	20*
0300	10:00	20	40	20	15	20	15	15	20
0400	11:00	—	40	20	15	20	15	—	20
0500	12:00	—	40	20	15	20	15	—	20
0600	1:00	—	40	20	20	20	20	20	20
0700	2:00	—	40	—	20	20	20	20	20
0800	3:00	—	40	—	20	20	20	20	20
0900	4:00	—	40	—	40	20	20	20	20
1000	5:00	—	20	—	40	40	40	40	20
1100	6:00	—	15	—	20	40	80*	40	—
1200	7:00	—	15	10	10	—	80*	20	—
1300	8:00	20	15	10	10	—	20	20	—
1400	9:00	20	10	10	10	—	20	15	20
1500	10:00	20	10	10	10	—	15	15	20
1600	11:00	20	10	10	10	—	15	20	—
1700	12:00	—	10	10	10	—	15	20	—
1800	1:00	—	15	10	10	—	10	—	—
1900	2:00	—	15	10	10	—	10	—	—
2000	3:00	—	15	10	10	—	10	10	20
2100	4:00	—	15	15	10	15	10	10	20
2200	5:00	20	20	15	10	15	10	10	10
2300	6:00	20*	20	15	10	15	10	10	15

*Look at next higher band for possible openings.

Heath IG-102 RF Signal Generator — $25. Both for $40. Heath HM-102 SWR/wattmeter — $30. I ship it all for $240! George Ritter, WB8EPE, (614) 587-7290 (work); (614) 366-3970 (home).

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FOR SALE: Drake DC-4 mobile power supply $49. Heathkit sixer $20. KØGXI, 4018 Ontario, Ames, IA 50010.

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DATABOOKS, IC, TTL, electronics books and engineering magazines from Eng. library. Exc. modern material. Also some older Ham magazines & service manuals. Send SASE for 2-pg. list. J.B. Cohen, 200 Woodside Ave., Winthrop, MA 02152.

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RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

WANTED: Digital dial frequency counter for TS820 Kenwood. Please write price to Dave, PB 76, Fenwick, LØS ICØ, Ontario, Canada.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature. Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

KENWOOD TS180S w/DFC, cw/dual SSB filters, $650.00; Drake R4B, 10 extra crystals, $335; Sony ICF-2001 digital AM/FM/SW portable, $255; Millen 90651 G.D.O., coils w/rack, probe, $45.00; MFJ-752 SSB/cw superfilter, $40.00. All line, w/manuals. WA7ZYQ, (208) 245-2070.

QSL ECONOMY: 1000 for $12. SASE for samples. W4TG, Box F, Gray, GA 31032.

MUST SELL: Radios, assembled boards, parts from pilot line build of the high quality Amtech 225A synthesized 2m FM transceiver. Business size SASE (40 cents postage) for list. Very low prices! Bill Weaverling, 3060 27th Ave., Marion, Iowa 52302. (319) 377-7927.

TUBES, TUBES wanted for cash or trade: 340TL, 4CX1000, SCX1500. Any high power or special purpose tubes of Eimac/Varian. DCO, 10 Schuyler Avenue, No. Arlington, NJ 07032. (800) 526-1270.

PICTURE QSLs — quality photo and standard cards. Free samples and information. Planet Publishing, P.O. Box B, Martinsville, IL 62442.

MATCHING NETWORKS AND FILTER DESIGN are fast and easy with your HP-41C and our programs. Write Software Specialties, Inc., Dept. HR/1, Box 329, Springboro, OH 45066.

WANTED: MS connectors (new or used), synchros, etc. Send list, Bill Williams, P.O. 7057, Norfolk, Virginia 23509.

WANTED: Micor and Master II base stations, 406-420 MHz. Any solid state 2 and 6 GHz microwave equipment, AK7B, 4 Ajax Place, Berkeley, CA 94708.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

VERY In-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

EXCELLENT OPPORTUNITY IN SUNNY SOUTHWEST. Join our staff of 20+ technicians. Motorola MSS servicing 2-way radio, mobile telephones, micro-wave and CCTV equipment. Openings at all levels for technicians. Contact: Jim Strickland, K5EXB, Circle Communications Co., 2740 South Freeway, Ft. Worth, Texas 76104. Phone: (817) 923-7334.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drill. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

BUY-SELL-TRADE Send $1.00 for catalog. Give name address and call letters. Complete stock of major brands new and reconditioned amateur radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. (913) 381-5900.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

Coming Events

ACTIVITIES

"Places to go..."

FLORIDA: The Treasure Coast Hamfest, February 20, Vero Beach Community Center. Prizes, drawings, Q.C.W.A. luncheon. Admission $2.00 advance; $2.50 door. Talk in on 146.13/73, 146.04/64, 146.52/52, 222.34/223.94. For information: P.O. Box 3088, Beach Station, Vero Beach, Florida 32960.

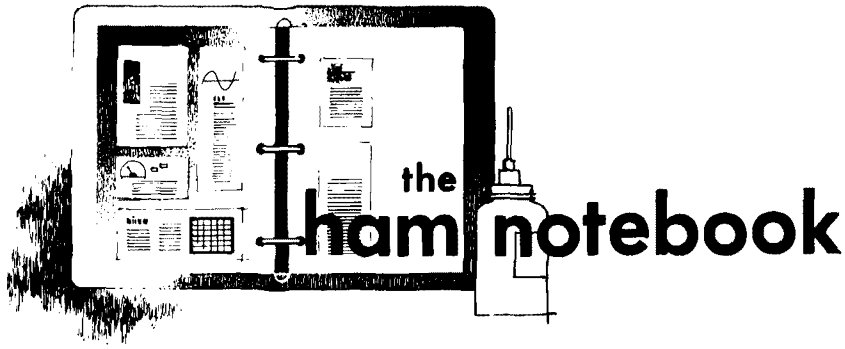
PLAYBOY CLUB: Plan ahead now to attend the ARRL Hudson Division Convention, October 30-31, 1982, at the Playboy Club, Great Gorge, McAfee, NJ. For info send SASE to HARC, Box 528, Englewood, NJ 07631.

INDIANA: The LaPorte Amateur Radio Club's Winter Hamfest, Sunday, February 28, Civic Auditorium, 8 AM. Donation: $2.50 door. Reserved tables $2.00 each. Write: P.O. Box 30, LaPorte, IN 46350.

MICHIGAN: The 12th annual Livonia Amateur Radio Club's Swap 'n Shop, Sunday, February 28, 8 AM to 4 PM, Churchill High School, Livonia. Door prizes, refreshments, free parking, tables. Talk in on 146.52 simplex. Reserved table space available. For information SASE to: Neil Coffin, WA8GWL, Livonia ARC, P.O. Box 2111, Livonia, MI 48151.

IOWA: The Davenport Radio Amateur Club's 11th annual Hamfest, Sunday, February 28, Davenport Masonic Temple, 7th and Brady Streets. Tickets $2 advance; $3 door. Tables $5 each plus $2 electrical hookup charge. 8 AM to 4 PM. Talk-in on WØBXR/Rpt at 146.28/.88 MHz. For tickets/tables write: Dave Johannsen, WBØFBP, 2131 Myrtle, Davenport, Iowa 52804.

TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums: air-conditioned exhibit area; large indoor/outdoor flea market. Make this Tennessee's largest hamfest. For more information: (dealers, tickets, reservations) N4BAO, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.



CW BFO crystal for the 75S-3

The Collins 75S-3 receiver uses the upper sideband BFO crystal (456.350 kHz) for reception of both upper sideband and CW. The EMISSION switch selects either of two filters, but the BFO crystal frequency remains the same. This provides a beat note of 1350 Hz when the signal is properly positioned within the filter passband. I found the note to be too high for my taste and got tired of using the tunable BFO each time for CW reception.

Investigation showed that EMISSION-switch section S9 has two lugs jumpered where the upper sideband BFO crystal (Y16) is attached, although the schematic does not show this. By removing the jumper, an extra CW BFO crystal was added, which creates a more pleasing beat note when using the CW filter position. In my case, a 455.300-kHz crystal (HC-33/U holder) was used, which produces a 300-Hz beat note.* See **fig. 1**.

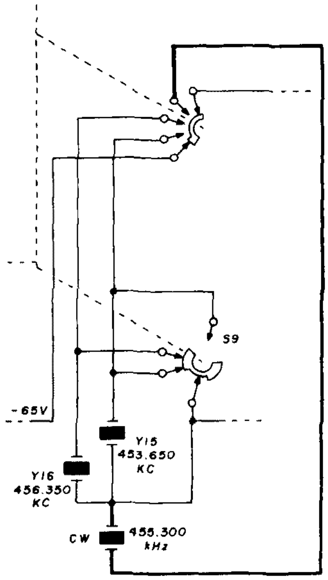


fig. 1. Heavy line shows addition of new CW BFO crystal to Collins 75S-3.

After cutting the jumper between the two switch lugs, ensure that the upper sideband crystal is soldered to its proper lug, then add the new CW crystal between its lug and the crystal common point at the terminal strip immediately behind the switch. Both lugs are easily accessible. With the receiver upside-down, front-panel toward you, the two lugs used are at the 11 o'clock upper sideband positions on the rear-most wafer.

When calibrating the receiver for operation close to the band edges, caution should be observed because the beat will differ between the upper sideband and CW positions by the frequency difference between the two crystals. This is the same precaution that must be taken when the tunable BFO is used. Once calibrated in a particular position, the setting will be accurate for that position of the EMISSION switch.

I've found, as have many others, that the lower CW beat note is much less tiring to listen to. Most of the high-frequency hiss and noise are eliminated, and copy approaches that of listening to a monitoring signal. The switch-selected CW position now provides both filtering and the preferred beat note at the flick of the switch.

Paul K. Pagel, N1FB

*F_{xtal} minus i-f equals F_{beat}; that is, $455.300 - 455.000 = 0.3$, or 300 Hz.

an rf power divider

Here's a variable rf power divider that's particularly suitable for UHF applications, and which:

1. Presents a matched load to the power source at all levels of power division.

2. Maintains a constant (90-degree) phase relationship between the two outputs.

3. Can be adjusted with a single control.

Consider the circuit of **fig. 2**. Matched loads are assumed at outputs **A** and **B**. If all components are normalized to the characteristic impedance of the lines, the matched loads will be unity, and the two shunt susceptances represented by the dual sliding shorts will be characterized as jB. Thus, at **A** we'll have an admittance of $1 + jB$. At point **C** there will be merely the susceptance jB, which when translated a quarter wavelength to **B** and combined with the load, becomes $1 + \frac{1}{jB}$. Both these complex admittances will again be inverted as they are translated an additional quarter wavelength to be combined at the input port. The input admittance thus becomes:

$$\frac{1}{1 + jB} + \frac{1}{1 + \frac{1}{jB}}, \text{ which becomes}$$

$$\frac{1}{1 + jB} + \frac{jB}{1 + jB} = 1 \qquad (1)$$

Therefore, as long as the loads are matched, and the two shunt susceptances are equal, a matched load will be presented to the power source.

Obviously the sum of the two output powers must equal the power input to the divider. Power, of course, is proportional to the square of the voltage, and as $sin^2\theta + cos^2\theta = 1$, the amplitudes of the output voltages must have a sine-cosine relationship.

A vector diagram, showing the action as the length of the sliding shorts vary from zero to a quarter wavelength, is shown in **fig. 3**. With

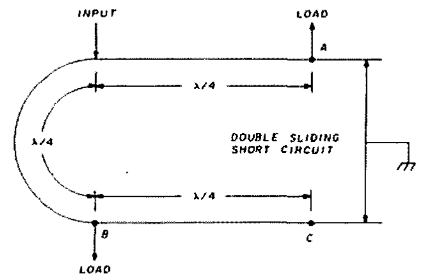


fig. 2. Power divider schematic. The double sliding short provides controlled shunt susceptances to obtain unity input admittance and thus a matched load to the input at all levels of power division.

a length of zero, output **A** (**fig. 2**) is shorted, while the quarter-wavelength, **BC**, allows output **B** to receive the full output.

When the lengths are increased to a quarter wavelength, the picture is reversed. Intermediate points will lie

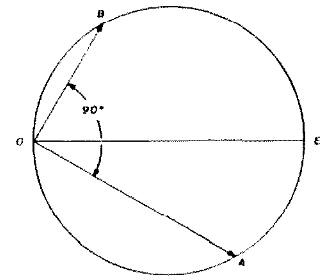


fig. 3. Vector diagram illustrating what happens in the power divider as the length of the sliding short circuit varies from zero to a quarter wavelength.

on semicircles, with **OE** as a common diameter. The geometry of the figure further dictates that the phase angle between **OA** and **OB** is 90 degrees at all times.

A dual sliding short is indicated in **fig. 2**. However, any method of producing identical controlled shunt susceptances will give the same results. If a zero-to-total changeover is not required, a small, two-section variable capacitor may be the answer. In a stripline configuration, a dielectric element can be used to vary the electrical length of the lines at **A** and **C**.

Henry S. Keen, W5TRS

KENTUCKY: The annual Glasgow Swapfest, Saturday, February 27, 8 AM til everyone goes home, Glasgow Flea Market Building, 2 miles south of Glasgow off Highway 31E. Large heated building, free parking, door prizes, free coffee, large flea market and a friendly gathering. Admission: $2.00 pp. One free table per exhibitor with extras available at $3.00 each. Talk-in on 146.34/94 (primary) or 147.63/03 (alternate). Additional information: WA4JZO, 121 Adairland Ct., Glasgow, KY 42141.

MICHIGAN: The Cherryland Amateur Radio Club's ninth annual Swap 'N Shop, Saturday, February 13, Immaculate Conception Middle School gymnasium, 218 Vine Street, Traverse City. Doors open 8 AM to 2:30 PM. General admission $2.50, single tables $3.00. Talk-in on 146.85 or 146.52 simplex. For information: Jerry Cermak, K8YVU, Chairman, 3905 Slusher Rd., Traverse City, MI 49684. Please SASE.

NEW JERSEY: The Split Rock Amateur Radio Association's annual equipment auction, Thursday, February 25, Morris Plains VFW Post #3401, Route 53, Morris Plains. Doors open 7 PM. Auction 8 PM sharp. Admission free. Please limit items to working electronic equipment — no junk. Bag or box loose parts. The club will take 10% commission on all individual sales up to $50. Over $50, a $5 commission will be taken on individual sales. Payable in cash only. Refreshments and plenty of parking. Rain date: Thursday, March 4, same time/location. For information: P.O. Box 3, Whippany, New Jersey 07981.

NEW YORK: Oneida County Mini-Fest and Flea Market, February 20, Oneida County Airport, Oriskany. For further details: (315) 736-0184.

OHIO: The Mid-Winter Hamfest/Auction, Sunday, February 14, Richland County Fairgrounds, Mansfield. Doors open 8 AM. Tickets: $2.00 advance; $3.00 door. Tables $5.00 advance; $6.00 door. Half tables available. Talk-in on 146.34/94. For info, advance tickets or tables, SASE to: Harry Frietchen, K8HF, 120 Homewood Road, Mansfield, OH 44906. (419) 529-2801.

OHIO: The Cuyahoga Falls Amateur Radio Club's 28th annual electronic equipment Auction and Flea Market, Sunday, February 28, North High School, Akron, 8:30 AM to 4 PM. Tickets $2.00 advance and $2.50 door. Prizes: First — Kenwood TS130S, second — Icom 3AT, third — Icom 2AT. A 16k TRS-80 Model III will be raffled at $2 a chance. Sellers bring own tables or rent for $2. Free parking. Check-in on 146.04/64. Details from CFARC, P.O. Box 6, Cuyahoga Falls, OH 44222 or call K8JSL (216) 923-3830.

VIRGINIA: The Vienna Wireless Society's 9th annual WINTERFEST '82, February 28, 8 AM, Community Center, 120 Cherry Street, Vienna. Displays, dealers, indoor flea market and "Frostbite" tailgating. Tables $5 and $10. Prizes include a Kenwood TS-830S hf transceiver, Icom IC-25A, mobile 2m rig, Santec HT-1200 handheld. Hourly drawings for accessories and books. Tickets $3.00 includes one chance for prizes. Talk-in on 31/91 and 146.52 simplex. For info: SASE to Winterfest '82, Vienna Wireless Society, P.O. Box 418, Vienna, Virginia 22180 or call Ray Johnson (703) 938-8313.

CINCINNATI ARRL '82: Hamilton County ARPSC invites all hams to participate in the second annual Ohio State Convention. Two full days of amateur activities; forums, meetings, exhibits, flea market, and more! This ALL INDOORS activity will take place on Saturday and Sunday, February 27 & 28. For further information contact Cincinnati ARRL '82, Committee for Amateur Radio, P.O. Box 46311, Cincinnati, OH 45246. Dealer and exhibitor inquiries invited. Registration $4, Flea Market $3.

NEW JERSEY: The Old Bridge Radio Association's second annual auction, February 28, Cheesequake Firehouse, Route 34 (Perrine Road), Old Bridge. Computer, electronic and Amateur Radio equipment. Admission: $1.00 includes chance at many door prizes. Doors open 11 AM. Sale starts 11:30. Club commission — 10% on first $100 of selling price; 5% on remainder. Refreshments available. Talk-in on .72/.12, .34/.94 and .52. For information: Fred, WA2BJZ, (201) 257-8753.

OPERATING EVENTS
"Things to do..."

FEBRUARY 7 THROUGH 9: NH-VT QSO Party. 2100Z, 7 Feb. to 0500Z, 8 Feb.; 1100Z, 8 Feb. to 0100Z, 9 Feb. Frequencies: Phone — 3930, 3960, 7230, 7260, 14280, 14320, 21360, 28570, 50110, 144.2. CW — 3530, 3760, 7030, 7130, 14080, 21060, 21150, 28070, 144.1. Exchange: NH, VT stations send QSO number, RST, County, State. Others send QSO number, RST, State, Country. Certificate awards. SASE for results. Send logs/facsimiles, name, license class, address, NLT 15 March 1982 to: Rex Lint, K1HI, 10 Hartwood Dr., Merrimack, NH 03054.

Continued on page 83

HAM CALENDAR February

W1AW Schedule

October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M., TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M., TTh: 9 A.M., TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M., MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M., TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M., TTh: 6 A.M., TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M., MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M., MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
	WEST COAST BULLETIN – 9PM PDT (8PM PST) (0400UTC) – 1. **1**	**2**	**3**	**4**	**5**	**RSGB** – 7-MHz Contest (phone) – **8-7.** **FLORIDA STATE CONVENTION** – Miami, FL. Contact W4WYR – **6-7.** **6**
NH-VT QSO PARTY – **7-9.**** **ARRL HAMFEST** – Arlington Heights, IL. Contact WB9PWM – **7.** **7**	**8**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **9**	**W1AW QUALIFYING RUN** – **10.** **10**	**11**	**12**	**OREGON QSO PARTY** – **13-15.**** **YL-OM Contest** (phone) – **13-14.**** **13**
14	**WEST COAST BULLETIN** – 9PM PDT (8PM PST) (0400UTC) **15.** **15**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **16**	**17**	**18**	**19**	**INTERNATIONAL DX CONTEST** – CW – **20-21.** **20**
21	**22**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **23**	**W1AW QUALIFYING RUN** – **24.** **24**	**25**	**26**	**OHIO STATE CONVENTION** – Cincinnati, OH. Contact K8JE – **27-28.** **27**
ARRL HAMFEST – Cuyahoga Falls ARC, Akron, OH. Contact Bill Sovinsky, 2305-24th St., Cuyahoga Falls, OH 44223 – **28.** **ARRL HAMFEST** – Livonia ARC, Livonia, OH. Contact WA8GWL – **28.** **ARRL HAMFEST** – Vienna Wireless Society, Vienna, VA. Contact K5RJ – **28.** **28**						

**see coming events

FEBRUARY 13 AND 14; FEBRUARY 27, 28: YL-OM Contest. Phone starts Saturday, February 13, 1800 UTC, ends February 14, 1800 UTC. CW starts Saturday, February 27, 1800 UTC, ends February 28, 1800 UTC. All licensed men and women operators worldwide are invited to participate. OM's call "CO YL" and YL's call "CO OM." OPERATION: All bands may be used. No cross band operation. Nets/repeaters do not count. EXCHANGE: Station worked, QSO number, RS(T), ARRL section or country. Log entries must show time, band, date, and transmitter power. CW and Phone are separate contests. Submit separate logs for each contest. Awards: Cups/certificates. Send logs to: Sandra Heyn, WA6WZN, 962 Cheyenne Street, Costa Mesa, CA 92626 no later than April 5, 1982.

FEBRUARY 13 AND 14: Oregon QSO Party sponsored by Brand-X Amateur Radio Association from 1700Z Feb. 13 until 0800Z Feb. 14. From 1500Z Feb. 14 until 0000Z Feb. 15. Suggested frequencies: Phone — 1810, 3920, 7260, 14,300, 21,370, 28,600. CW — Send "CO OR" — 60 kHz up from bottom of each band. Novice/Tech — 10 kHz up from bottom of each Novice/Tech band. Logs must be received by March 8, 1982. Mail to: Tim Burdick, WA7NVT, 138 N. 20th St., Philomath, OR 97370. SASE for results.

FEBRUARY 14. The Oregon Tualatin Valley Amateur Radio Club will operate a special event station, Sunday, February 14, commemorating the 123rd birthday of the State of Oregon, admitted to the Union on Valentine's Day in 1859. KA7CTP will operate from 9 AM to 6 PM PST on or near frequencies of 14.280, 21.360 and 28.510. An attractive certificate QSL will be awarded. Send 9 × 12 SASE or $1.00 to Marshall D. McKillip, 1175 NW 128th Street, Portland, Oregon 97229.

THE JUNIATA VALLEY AMATEUR RADIO CLUB'S 25th anniversary will be commemorated by a special event station operating at various times starting January 1. The club call is K3DNA, located in Lewistown, PA., Mifflin County. The station will operate on different bands, CW or phone. One contact with a club member entitles an operator to a club certificate.

FEBRUARY 5-14. The North Okanagan Radio Amateur Club along with the Vernon Winter Carnival Society are sponsoring a certificate to celebrate the 22nd annual Vernon Winter Carnival, Western Canada's largest. We will be operating daily from 2100-2400 Zulu and on Feb. 7 from 2000-0200 Zulu. Frequencies: 28.575, 21.375, 14.295 ± QRM. Send log information of 3 QSO's with Vernon area stations or one contact with club station (VE7NOR) to P.O. Box 1706, Vernon, BC. V1T 8C3.

MOVING?

KEEP HAM RADIO COMING . . .

If possible let us know four to six weeks before you move and we will make sure your HAM RADIO Magazine arrives on schedule. Just remove the mailing label from this magazine and affix below. Then complete your new address (or any other corrections) in the space provided and we'll take care of the rest.

ham radio Magazine
Greenville, NH 03048

Allow 4-6 weeks for correction.

Thanks for helping us to serve you better.

Here's my new address:
Name ______ Call ______
Address ______
City ______ State ______ Zip ______

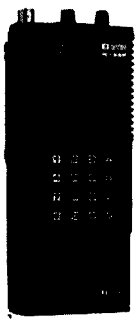
AFFIX LABEL HERE

More Details? CHECK — OFF Page 100

NEW products

ICOM IC3A/3AT 220-MHz handheld

ICOM announces a "second cousin" to the popular IC-2A series, the IC-3AT for the 220-MHz band. The IC-3AT is essentially identical in appearance, size, and features to the IC-2A series. All accessories, including battery packs, chargers, and microphone are completely compatible between the IC-2AT and IC-3A series, so accessories purchased for the IC-2A can also be used on the IC-3AT.

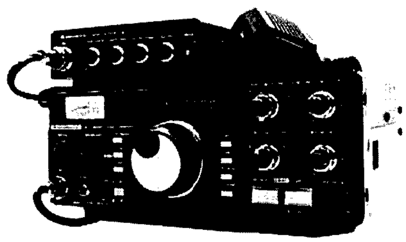


The IC-3AT also includes a sixteen-button Touchtone™ pad. It covers the entire 220-MHz band from 220-MHz to 224.99 MHz and is set up for both duplex and simplex operation. The power output is nominally 1.5 watts with the standard IC-BP3. The IC-3A system comes complete with IC-BP3 NiCd battery pack wall charger, belt clip, rubber duckie, and wrist strap. For more information, contact ICOM AMERICA, INC., 2112 116th Ave. N.E., Bellevue, Washington 98004.

Touchtone is a registered trademark of American Telephone and Telegraph Company.

TS-660 Quad Bander

Trio-Kenwood Communications announces a unique, new radio, the TS-660 "Quad Bander," an all-mode transceiver designed for operation on 6, 10, 12, and 15 meters. The TS-660 features built-in dual VFOs, a five-channel memory, memory scan, fm, SSB(USB), CW, an a-m operation, fluorescent digital frequency display, squelch, UP/DOWN pushbutton frequency control on the microphone, UP/DOWN pushbutton bandswitch, i-f shift, CW semi break-in with sidetone, S-meter, RIT control, and noise blanker.



The rf output power is 10 watts on SSB, CW, and fm, and 4 watts on a-m. The Quad Bander operates on 13.8 Vdc drawing 1 ampere in receive, 4 amperes in transmit. Additional information may be obtained by contacting Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

surge shunt

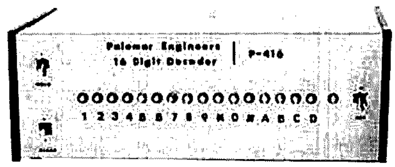
The R.L. Drake Company announces its new model 1549 Surge Shunt. The Surge Shunt protects solid-state communications equipment from damage by voltage transients entering the antenna system. These transients are usually caused by atmospheric static discharges or nearby lightning strikes.

The Surge Shunt can be used with receivers and with transceivers of up to 200 watts output. Convenient UHF-type coaxial connections are used, permitting use well into the UHF range. Price is $24.95.

For more information, contact R.L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342.

sixteen-digit DTMF decoder

New Model P-416 decoder converts incoming Touchtone™ signals to dc outputs on sixteen lines. Indica-



tor lamps show which digit is being received. Outputs will drive power relays directly and are either momentary or latched as selected by a panel switch.

Decoding is by digital logic with quartz crystal frequency control for long-term stability and operation over wide temperature variation. Operates on 115-volt ac power. Price is $385.

Write Palomar Engineers, 1520-G Industrial Ave., Escondido, California 92025 for further information.

12-ft antenna for 20/15/10

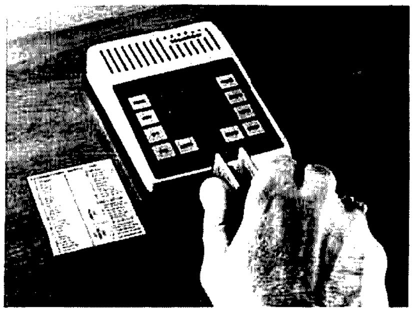
At last, a truly high performance short antenna designed specifically for hams with limited space. Where larger antennas require installation on costly towers or close to roof-top level, the lightweight and small DAP-31 makes this antenna ideally suited for mounting high and in the clear, using low-cost TV masts or tripods. Only the highest quality materials are used: 6061-T6 aluminum alloy for the element and capacitive-hat frames; fiberglass rod center insulator; aluminum or stainless steel hardware for all electrical connections; ultra-lowloss, air-wound, large-diameter inductor wound with 1/4-inch aluminum tubing.

The model DAP-31 sells for $165 with balun. For more information, contact Diversified Antenna Products, 2330 W. National Ave., Milwaukee, Wisconsin 53204.

memory keyer

Heathkit's SA-5010 uMatic Keyer uses a custom microprocessor to provide up to ten buffers for storing up to 240 characters of text or commands. These variable-length buffers eliminate wasted memory space by letting the user store text in several buffers and then string them together in any sequence. Command strings can also select the speed, weight, spacing, and auto-repeat count for each message so selected.

The SA-5010 employs a 20-position keypad for entries, and features easy-to-use integral capacitive touch paddles. A rear panel jack is provided for use of a mechanical paddle with the SA-5010, if so desired. A practice mode sends random code groups of random length and selectable types. The 100 different random sequences are repeatable, so the ham can check copy for accuracy. All 100 sequences are altered each time the keyer is turned on, said to give a total of 6,400 different practice sessions. Each sequence sends approximately 3,000 characters before repeating. The user can choose any speed between 1 and 99 words per minute, and any of 11 weight settings.



Text may be manually inserted into a buffer message being sent. A pause may be stored into text or command strings to cause the keyer to pause automatically for manual insertion of, for example, a station's RST report. The SA-5010 allows entry of text at whatever speed and weight are comfortable for the user. It can be sent at any other settings desired.

NEW products

CMOS memory with battery backup retains the buffer contents, as well as the last-selected speed, spacing, weight, and repeat count whenever the keyer is turned off or unplugged. Built-in diagnostics check the microprocessor each time the keyer is turned on, and also test buffer memory whenever the uMatic Memory Keyer is reset. For the left-handed CW operator, a special two-key function reverses the paddles. And the keyer even remembers to turn itself off if the user forgets.

Mail order priced at $97.95, FOB Benton Harbor, Michigan, the SA-5010 features built-in side tone oscillator and speaker with variable pitch and volume controls. Phone jack and ear phone are included for private listening. A plastic case covers the die-cast zinc base, which is weighted to reduce movement during keying. The keyer requires the optional 120 Vac Heathkit PS-5012 power supply. Step-by-step instructions make this Heathkit project a two-evening kit. Write Heath Company, Dept. 350-115, Benton Harbor, Michigan 49022.

2-kW antenna tuner

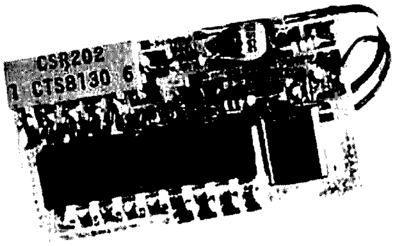
Ten-Tec announces a new 2-kW antenna tuner/SWR bridge/power meter. The new tuner uses a reversible "L" configuration with a silver-plated roller inductor, high-voltage variable capacitor, and selectable fixed capacitors for greater versatility in impedance matching. The design automatically provides a low-Q, minimum-loss path when properly adjusted. Power ratings are 2 kW PEP, and 1 kW CW. Frequency range is 1.8 to 30 MHz. Model 229 matches conventional 50-ohm unbalanced outputs of transceivers or linear amplifiers to a variety of balanced or unbal-

anced load impedances. Antennas such as dipoles, inverted Vs, long random wires, Windoms, beams, rhombics, mobile whips, Zepps, Hertz, and similar types can be matched. A built-in balun converts one antenna to a balanced configuration if desired.

The built-in SWR bridge and dual-range power meter indicates SWR from 1:1 to 5:1 and power from 10 to 2000 watts. Model 229 net price is $249.00. For full information, write Ten-Tec, Highway 411 East, Seiverville, Tennessee 37862.

CTCSS encoder

Communications Specialists introduce the new SS-32M micro-miniature programmable CTCSS encoder for use in the Icom IC2AT handheld. The unit is based on the popular SS-32 encoder and is programmable

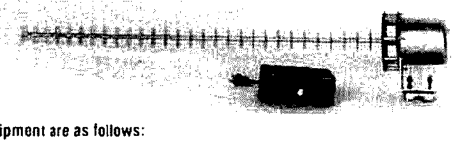


using jumpers. Measuring just 1.45 × 0.8 × 0.13 inches, the SS-32M may also be used in other applications where size is critical. Priced at $29.95.

A catalog is available on request. For more information, write Communications Specialists, Inc., 426 West Taft Avenue, Orange, California 92667.

Astatic's MK-I microphone

The Astatic MK-I Mobile King transistorized dynamic noise-cancelling microphone provides clear transmission for close talking. The MK-I has frequency response tailored for maximum voice clarity with 360-degree minimization of background noise.



NEW products

The handheld microphone is designed for CB, Amateur Radio, and SSB communications. A soft lip guard ensures proper close talk spacing.

The MK-I has a conveniently positioned press-to-talk lever and external slide controls for volume and tone. The controls permit easy accessibility for correct modulation level and tone quality. Power is supplied by a 9-volt battery. The solid-state amplifier provides output impedance for compatibility with inputs of most transceivers. The six-wire coil cord allows virtually any type of transceiver hookup, including relay and electronic.

Maximum output level is −30 dB below 1 volt/microbar at 1 kHz into 1-megohm load. Output adjustment is 40 dB minimum range. Impedance: 5000 ohms maximum.

For more information contact The Astatic Corporation, Conneaut, Ohio 44030.

40-meter monobanders

KLM introduces two new monobanders for 40 meters. The two-element 7.2-2 and three-element 7.2-3

offer substantial gain and F/B coupled with modest size. Their design and performance characteristics are based on KLM's well known four-element "Big Sticker" but require considerably less airspace, and are usable with most standard ham rotators. Lossless linear-loading keeps element length to 46 feet and permits stacking within 4 feet of 20 meter beams.

The 7.2-2 sits on a 16-foot boom and weighs only 45 pounds. The 7.2-3 has a 32-foot boom, supported by stainless steel overhead guy cables and weighs 70 pounds. Both employ the same materials and construction as all of KLM's full size monobanders: 6063-T832 aluminum alloy elements and boom (3 inch O.D. × 0.065 inch wall), Lexan insulators, and all stainless steel hardware (except U-bolts). Each is supplied with KLM's 1:1 4-kW PEP ferrite balun.

For more information on these and other KLM antennas contact: KLM, P.O. Box 816, Morgan Hill, California 95037.

Hamtronics® repeater modules

Hamtronics, Inc., long noted for fine quality fm transmitters and receivers commonly used for building repeaters, has now completed its line of repeater modules by offering inexpensive COR and CWID modules.

The 3-inch-square COR module kit ($29.95) contains an electronic relay to actuate the transmitter when the receiver squelch opens. Adjustable tail and time-out timers are provided on the board as well as an audio mixer to combine the ID tone with the receiver audio for application to the transmitter. Another nice feature is a separate speaker driver amplifier stage which allows a local speaker to be operated completely independently from the repeater audio level setup control, without using hard-to-find L-pads.

The 3 × 7 inch CWID module kit ($59.95) contains a tone generator controlled by a 158-bit diode matrix. Adjustments on the board control the

NEW products

ID speed, tone, and time. A special output filter eliminates the key clicks found on many repeater ID'ers. Although many articles have appeared recently on PROM ID'ers, a survey by Hamtronics indicates that most still prefer a diode matrix because it can be easily reprogrammed at any time without further expense. The CWID module is constructed on a double-sided PC board with plated-through holes for easy assembly.

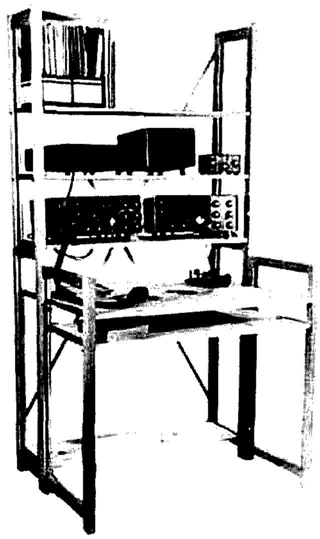
The CWID and COR modules are designed to be used with Hamtronics® transmitter and receiver modules as well as most other types.

For further information, contact Hamtronics, Inc., 65F Moul Road, Hilton, New York 14468, or phone 716-392-9430. A complete 1981 catalog, which includes all Hamtronics® fm and SSB equipment, is yours for the asking. (For overseas mailing, please send $2.00, or five IRCs.)

operation desk

Ricker Equipment, Inc., of Fort Wayne, Indiana, has introduced an operating desk for use with ham radio equipment and computers, called Shack Desk. It makes use of the space above desk-top level better than any other unit on the market. Shack Desk is made of wood — prefabricated uprights and lumber shelves. The shelves are edge-glued, designed to carry the weight of ham gear including linear amplifiers. The standard Shack Desk provides a desk top 30 inches deep by 36 inches wide with four shelves above the desk top level that are 12 inches deep and 36 inches wide. A second 18-inch-deep shelf 36 inches wide under the desk-top level provides handy storage for reference material. The unit is open-construction at the sides and back for maximum air circulation. The user may enclose the ends or back if desired, with lumber or paneling readily available.

For hams with plenty of space, there are larger Shack Desk units available. Shack Desk is sold unfinished, with the particular finish left up



to the individual user. For further information, contact Ricker Equipment, Inc., P.O. Box 12304, Fort Wayne, Indiana 46863.

Volume 4: Disassembled Handbook for TRS-80

Volume 4: Disassembled Handbook for TRS-80 is the title of a newly released volume by Richcraft Engineering Ltd. that presents Morse code, Baudot, and ASCII programs for the Model I and Model III TRS-80 microcomputers.

Volumes 1 and 2 of the *Disassembled Handbook* series introduce the newcomer to assembly-language programming to the use of multifaceted CALLs in Level 2 ROM. As it says in the foreword to volume 4, these CALLs can "often save the student 1 to 2 years (of) study, and hours/pages of programming effort for most

any program written in assembler." Volume 3 of the series is system oriented, and includes programs and hardware for implementing spooling, interrupts, interfacing to the outside world, A/D converters, D/A converters, and RS-232C adapter applications. Volume 4 presumes a working knowledge of Level 2 ROM.

Volume 4 of the series is aimed at radio communications. The material is presented in a format that will work with most any Model I TRS-80 with Level 2 BASIC and at least 16K of memory, *without* an expansion interface and RS-232C adapter. The programs will work with or without disk. Each chapter includes the modifications necessary to enable Model III users to make the minor changes necessary to ensure that all the programs in this volume will work as well on their machine as on the Model I.

There are ten chapters in Volume 4, dealing with the following subjects:

Chapter 1: Converting parallel ASCII from the keyboard to serial Morse output via the cassette output line. Code speed may be selected from 8-800 words/min.

Chapter 2: The dots, dashes, and spaces of Morse code are divided down into finite segments and the keyboard scanned during the element's output period.

Chapter 3: Converting serial Morse code input via the CASSIN line from the receiver's speaker to parallel ASCII presented to you on the video display.

Chapter 4: Combining the Morse transmit and receive programs into the single working entity. The CLEAR key serves as the operator's TRANSMIT/RECEIVE switch.

Chapter 5: Converting parallel ASCII input from the keyboard into serial Baudot radio teletype signals. Speeds of 60, 66, 75, and 100 words/min. may be selected.

Chapter 6: Converting serial Baudot input from the station's receiver to

NEW products

parallel ASCII that is presented to the operator on the video display.

Chapter 7: Combining the Baudot transmit and receive programs into a working entity. Twenty-two prepared messages may be selected and/or input a prepared message via keyboard.

Chapter 8: Converting parallel ASCII input from the keyboard into serial 110-Baud ASCII radio teletype signals.

Chapter 9: Converting 110-Baud serial ASCII radio teletype from the station receiver into parallel ASCII that is presented to the operator on the video display.

Chapter 10: Combining the ASCII transmit and receive programs into a working entity. Twenty-two prepared messages may be selected and/or input a prepared message via keyboard.

Volume 4: Disassembled Handbook for TRS-80 is written in a clear, question-and-answer format. It is available from Richcraft Engineering Ltd., #1 Wahmeda Industrial Park, Chautauqua, New York 14722.

tower trailer

For those special situations that require mobility, Aluma Tower Company introduces an all-steel trailer for transporting and erecting any Aluma aluminum or steel tower. Ideal for mobile demonstration work, civil defense, remote signal testing, and many other situations, the tower trailer combination is easily towed. Once in place, the tower is tilted up and cranked into position. The trailer acts as a secure base.

For more information, contact Aluma Tower Company, 1639 Old Dixie Highway, Box 2806, Vero Beach, Florida 32960.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CONTROLLER

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contents

Observation & Opinion

This month, we are presenting a guest editorial by Pat Hawker, G3VA. Pat is the author of the Technical Topics column in *Radio Communication*, the monthly magazine of the Radio Society of Great Britain. His column is read by Amateurs around the world, many of whom subscribe to *RADCOM* just to see what Pat has to say. Here is an example of his work, excerpted from the December, 1981, issue. I think you'll find it interesting. **Editor.**

ionospheric outlook

Those of us who depend on the ionosphere for most of our contacts have had, for many years, some inkling that man's activities may be introducing subtle change in those fickle layers. Why, for example, were there numbers of reports of apparently authentic long-delay echoes in the decade before 1939, yet so very few, if any, in modern times? The phenomenon of ionospheric cross-modulation and the creation of artificially enhanced layers resulting from very high power transmissions have been ascribed to increasing the temperature of free electrons; but does such radiation have any permanent effect? Then again, there is the very real worry that many aerosol sprays may eventually strip away part of our protection from high-energy ultra-violet rays. It is not only hf operators who have some cause to worry.

There continues to be genuine concern that high power ELF and VLF transmissions, such as those used for communicating with submarines or for the Omega navigational system, induce the precipitation of electrons from the earth's magnetosphere into the ionosphere. Such precipitation is believed to cause irregularities in the ionosphere sufficient to disrupt or degrade ELF and VLF communications. A research program aimed at determining whether such transmissions affect the free electron content of the ionsphere, and thus have effects beyond ELF and VLF range, is being undertaken by Lockheed under contract from the U.S. Office of Naval Research. This experiment includes a SEEP (stimulated emissions of energetic particles) satellite that will carry sensors able to observe electron precipitation while a number of high-power terrestrial transmitters are keyed on and off.

hybrid microelectronics

By now most of us have at least a nodding acquaintance with integrated circuits (including, these days, LSI, large scale integration, and VLSC, very large scale integration) and also, of course, with the use of discrete components assembled on printed circuit boards. But there is an increasingly important intermediate step, no longer considered a merely transitional stage, between the use of PCB assemblies and fully integrated circuits. This is the so-called hybrid technology, in which circuits are assembled as hybrid modules using "thick" or "thin" film circuits, often with special "chip" forms of discrete components.

Manufacturers often buy up standard types of IC devices in chip carrier form for fixing into the hybrid modules. The modules may finish up looking like large IC devices but inside may include single or multiple layers. A wide variety of enclosures and packages have been developed, some suitable for the dissipation of appreciable electrical power. Marconi, for example, has designed transmitter/receivers in hybrid form dissipating up to 100 watts.

Hybrid technology is already being used for large-volume consumer electronics in power-supply regulators, fusible resistors, car electronics, medical pacemakers, and the like. There do seem to be many potential applications in Amateur Radio equipment, provided that hundreds or thousands of identical modules are required. Clearly, the technique is not suitable for one-shot prototype equipment, but on the other hand it would be very well suited for kits or perhaps as building-block modules. For communications applications, hybrid technology has a useful advantage over fully integrated devices, in that, with the use of lasers, it is possible to accurately trim resistor values during manufacture. It can also provide significant size reductions, when compared with conventional PCB techniques.

Racal, for example, uses thick-film hybrid circuit modules for a number of communications units, including lightweight man-pack transceivers incorporating frequency-hopping (spread-spectrum) based on custom-LSI and thick-film-hybrid circuits. Indeed, this technology seems to offer quite substantial advantages over the rival techniques, in that it is rather more flexible and thus more suited to circuits requiring critical adjustment than is the fully integrated approach. But it is not a technology for experimental breadboard units!

Pat Hawker, G3VA

comments

burglar alarm RFI

Dear HR:

My neighbor installed an ULTRAR™ ultrasonic home alarm system by Universal. Soon after, the neighborhood was aroused by a series of false alarms. I traced the problem to my 25-watt 2-meter transmitter, 100 feet away.

A service man in the factory gave me the following information: A radio transmission will trigger the alarm; and the ultrasonic transducers should not be pointed at the window (where the 2-meter signals apparently enter). After hearing this, I suggested to my neighbor that he not send the alarm back, because they probably would not find anything wrong with it. I hope this will solve some puzzles of false alarms triggered by mobiles or stationary transmitters.

Kurt Bittmann, WB2YVY
Centereach, New York

a vote for Baudot

Dear HR:

Note was taken on a letter concerning slow ASCII, appearing in the June, 1981, issue of *ham radio*. It is my impression that the writer of the note has not taken into consideration the actual typing rate of slow ASCII — say 45.45 Baud. The typing rate is on the order of 41 words per minute. This results from the need for at least 11 bits in the ASCII frame, as compared with the 7.42 bits in the Baudot frame. There are many fast typists in the Baudot group; they would feel cramped if they had to handle things at a 41-WPM rate. Of course, if the parties concerned have plenty of time to make a transmission, the slow rate is of little consequence.

The Baudot Code, by virtue of its having fewer signaling elements, appears to be more efficient, suitable for teleprinter communications over hf radio circuits. In fact, the five-unit code is well standardized around the world, making it possible for many types of machines to intercommunicate. Telex is still five-unit based. It may be that the European people will not go overboard for ASCII, at least in the near future. Meanwhile, we have efficient microprocessor programs for converting ASCII to Baudot and vice versa, so let that serve for the time being.

I am quite well satisfied with the alphabet as contained in the Baudot code. After all, we are not sending business letters to each other over the air.

Robert H. Weitbrecht, W6NRM
Redwood City, California

proud to be a ham

Dear HR:

During my 23 years as a licensed Amateur I've never heard of John Reinartz until now. Of course I knew that Amateurs were responsible for introducing the use of short waves after WWI, but I never knew the details.

Thanks for this enlightening article. It makes one proud to be a member of the ham community.

David Raskin, W5TYL
Ranchos de Taos, New Mexico

AFSK generator

Dear HR:

WA3PLC was too pessimistic in his discussion of his AFSK generator in the July, 1981, issue. The third harmonic of a triangular waveform is 1/9th the amplitude, not 1/9 the power. It is thus 19 dB below the fundamental, not 9.5 dB.

In fact, total harmonic distortion (THD) of a triangular waveform is only 1.47 percent, versus 23.4 percent for a square wave. While both square and triangular waveforms are made up of an infinite succession of odd harmonics, the harmonic amplitudes are much lower with the triangular wave. By "flat-topping" the triangular wave in such a way that the rise and fall times are 1/3 cycle, all harmonics evenly divisible by three are eliminated. Total harmonic distortion of this waveform is only 0.215 percent better than that of many inexpensive "sine wave" generators.

Alan Bloom, N1AL
Santa Rosa, California

Regarding the letter from N1AL, he is correct about the third harmonic of a triangular waveform. The amplitude of the third harmonic is 1/9 of the fundamental as given by the equation in the article. Since power is given by $P = V^2/R$, the power ratio of the harmonics must equal the square of the amplitude ratio.

$$\frac{P3}{P1} = \frac{V3^2}{V1^2}$$

$P3P1$ = *power in 3rd harmonic, fundamental*
$V3, V1$ = *amplitude of 3rd harmonic, fundamental*

Since the amplitude ratio is 1/9, the power ratio is 1/81. Thus taking

$$10 \log P3/P1 = -19.1\ dB$$

Thus the AFSK modulator has better spectral purity than I had thought. This further reduces the need for the RC lowpass filter, but still, the higher margin of safety won't hurt either.

N1AL's remarks about the "flat-topped" triangle were interesting. The waveform would, however, be harder to generate with the "jumps" at 1/3 of the period unless it were done digitally. The triangle was used because only two components are required when the LM567 is used.

By the way, a perhaps more subtle error has shown up in the article. In the equation, t, is the time index, not the period.

Thomas B. Zeltwanger, WA3PLC
State College, Pennsylvania

(Continued on page 36)

presstop

Two-meter Amateur Radio outlawed? Not yet, but it could be very soon. Here's why.

A problem of significant importance to Amateur Radio is cable leakage from Community Antenna Television (CATV) systems. Interference *from* leaking cable systems into Amateur stations (and the reverse situation of interference *to* cable systems) is becoming an issue of increasing magnitude. Incidents of interference from leaking cable systems operating on mid-band frequencies to legitimate Amateur Radio operations, especially in the 144-148 MHz band, have increased at an alarming rate. The problem is aggravated by the inherent proximity of the cable systems to Amateur stations. Both operate in residential areas, and co-location is unavoidable.

Cable television is technically a nonbroadcast, or closed, service, and therefore no interaction between cable systems and any radio service should occur. In fact, however, this is far from true, and interference between cable systems and Amateur stations, often resulting in lawsuits against Amateurs in local courts, is increasing at a rate that demands FCC attention.

The cable television service is regulated by Part 76 of the FCC rules, just as the Amateur service is regulated by Part 97. Section 76.605 (a) (12) of the Commission's rules limits cable leakage to 20 microvolts per meter measured at a distance of ten feet from the cable at frequencies of 54-216 MHz. The main concern of the FCC is primarily with the potential for harmful interference to ground/air communications and navigation services. A leak measured at 20 microvolts per meter at ten feet can cause interference to a nearby Amateur receiver and, by the same token, such a cable leak will allow a significant amount of signal to enter the cable from a nearby high-power Amateur transmitter.

To further aggravate the situation, a Notice of Proposed Rule Making has been released by the FCC the intention of which is to relax the cable leakage requirements to a maximum level of 100 microvolts per meter measured at ten feet from the cable. The ARRL has taken a strong stand in this matter and has filed a brief opposing the proposal to relax leakage standards. An increase in permissible cable-signal leakage will have a more profound effect on Amateur Radio operations than on any other radio service.

The portion of a cable system that creates the biggest problems, in terms of cable leakage interference, is the drop cable from the pole to the home. The shielding of this flexible coaxial cable is less effective than is the solid aluminum hardline shielding around the cable on the pole. The drop cable moves around in the wind because of its flexibility, and the connectors used, being low-cost items, are far more subject to corrosion than are the communications-grade devices familiar to Amateurs. And all of these weaknesses are present in high-density areas, close to Amateur VHF stations. An increase in permissible leakage levels to 100 microvolts per meter at 54-216 MHz may not increase interference to aeronautical stations, but it most certainly will create or increase interference to Amateur 144-148 MHz operation. Further, cable leakage interference works both ways. Since Amateur stations are primarily located in residential areas, increases in the number of cases of interference to cable subscribers by local Amateur VHF transmissions will result.

Another potential problem for Amateurs resulting from the explosion in consumer electronics technology comes from the American Telecommunications Corporation (ATC), a subsidiary of General Dynamics Corporation. In a petition received by the FCC on December 8, 1981, ATC requests a waiver of part 15.7 of the rules to permit more liberal operating conditions for cordless telephones in the frequency band of 1.6-2.0 MHz. The FCC also received a letter dated October 27, 1981, from the Personal Radio Section of the Electronic Industries Association suggesting interim technical standards for cordless phones. The EIA letter is being considered a petition for waiver along with the ATC petition.

Both petitions propose to use carrier current techniques on the power wiring in the home. The EIA petition proposes that the maximum signal fed into the power line shall not exceed 500 milliwatts. The ATC petition states that the present standard in part 15.7 is not adequate and asks the FCC to set a new standard. What effect such a change in rules might have on 160-meter operation is not known, but surely it will be anything but beneficial. One wonders how many more attempts industry will make to muscle in on Amateur Radio frequencies.

microprocessor-based repeater controller

Some interesting ideas in repeater design

This article describes a fairly sophisticated repeater controller with autopatch that can be built for less than $175, depending upon parts availability and construction techniques. It is intended as a design example, which uses the power of the microprocessor in an Amateur Radio application.

A repeater controller is the device that, when connected to a transmitter and receiver, provides all audio and control signals for the complete operation of a repeater and, in this case, autopatch. In addition, we will interface the system with a control receiver, a logging recorder, and a phone line.

The repeater controller must monitor the repeater input (by means of the receiver squelch) and turn the transmitter on when a signal is present. This is referred to as the Carrier Operated Switch function (COS) sometimes known as the Carrier Operated Relay, or COR. This COS function also includes the time-out (typically 3-5 minutes) timer. Also included is a "courtesy beep." The time-out timer does not reset until a small amount of time has elapsed after a carrier disappears from the receiver input. When the timer resets, the controller indicates this reset by sending an audible beep on the repeater output. This beep forces users to pause between transmissions (or risk having the repeater execute time-out), so that other users may have access, particularly in an emergency.

The controller should have a well-defined external interface so that the rf portions of the repeater system can be easily connected. This requirement implies a standard level for audio signals and TTL-compatible inputs and outputs for the logic and control signals.

The logic polarity of the control lines should be chosen so that, when an input is disconnected, the tendency for TTL gates to default to a logic 1 keeps the controller in a reasonable state. For example, pulling the receiver squelch line, which is active low, does not inadvertently cause the controller to lock the transmitter on. Audio inputs should be of high impedance and outputs of low impedance to minimize loading effects. The phone-line interface should be 600 ohms.

design considerations

Our first design goal was to keep hardware to a minimum. We built the entire project on three 5 by 7 inch (12.7 by 17.8 cm) circuit boards. (Wire-wrap techniques will yield even smaller areas.) In keeping with this goal, we implemented functions such as COS and the Morse identifier in software, as opposed to the more traditional hardware approach. The entire system is of solid-state construction except for the phone-line relay.

The second design goal was a fairly extensive set of features. We needed a means for changing the repeater call sign without a major software change. Multidigit Touchtone™* commands were desired. We also included a software-based real-time clock to aid in autopatch logging.

*Touchtone is a registered trademark of the American Telephone and Telegraph Company.

By **Bob Witte, KB0CY**, 2253 Evelyn Court, Loveland, Colorado 80537

FCC compliance

It was impossible for our repeater group to supply a control operator for the system 24 hours a day. The FCC's recent interpretation of the rules regarding repeaters requires that a control operator be present when an autopatch is in use. To comply with this rule and still provide a means of accessing the autopatch for emergencies, we used a procedure in which, if a special access code is used, the autopatch can be accessed regardless of control-operator availability; however, only the number 911 (emergency telephone number in our area) can be dialed. This restriction is enforced by the processor monitoring the tone-decoder output.

The software also supports enhanced use of the repeater identifier to include repeater status with respect to autopatch availability and emergency power. The letters **AP** appear after the call sign if the autopatch is available; the letters **BAT** appear if the repeater is operating from emergency (battery) power.

The IDer sends the word **LOVELAND** at the end of the ID according to the following algorithm: if the repeater has been idle for more than ten minutes, the suffix (**LOVELAND** in this case) is always appended. If the repeater has been active, then the suffix is added only on every fourth ID so that it doesn't become annoying.

The suffix is control-operator programmable to any arbitrary message up to 24 characters. Thus, the repeater functions somewhat as a "billboard" for the club, with a typical message being **MEETING SATURDAY**.

You might ask if anyone really listens to all this Morse code from the repeater. The answer is that anyone interested in using the autopatch soon picks up the key letters **AP** regardless of his code speed. The message suffix scheme has worked out quite well as it takes only a small percentage of the membership copying the ID and commenting on its message to keep repeater users informed. Perhaps it provides, at least, a small incentive for Technician-grade licensees to increase their code speed!

The controller operates from a 13.6-volt supply (12 volts nominal), as does all the equipment at our installation. This allows one common 12-volt supply with automatic switching to battery backup. The power supply has a TTL-compatible output, which indicates the source of power in use.

hardware organization

The hardware is organized into three separate subsections mapped into three separate boards, but this is certainly optional.

decoder board

The decoder board (**fig. 1**) has two functions, to decode Touchtone signals fed to it from either the control receiver or audio board and to generate Touchtone signals controlled by the local (front panel) pad. (The local pad could be eliminated, but is a useful debugging tool.)

The audio source for the decoder is chosen by two analog switches (U1), which are controlled by the control receiver squelch line so that the control receiver always has priority. U2 level shifts the TTL control inputs. The tone decoder (M-917) is a decoder module made by Teletone.

A properly decoded tone is signalled by the strobe (pin 6 of M-917) going high just after the binary code appears on line D0 through D3. These lines are level-shifted by the 4050 CMOS buffer (U3), and are further buffered by TTL drivers U4,U5. The four right-column keys (**A**,**B**,**C**,**D**) are further decoded by U6 to provide active low, single-line outputs. One of these outputs is connected to the remote reset line on the processor board and can be accessed by the control link in case of processor failure. U5 was included to buffer the signals to a set of front-panel LEDs, which display the decoder outputs (**Table 1**).

The encoder uses a Motorola 14410 chip.[1] Some autopatch systems regenerate the Touchtones as they enter the system; we chose not to add the extra complexity and have found the system to be quite reliable.

audio board

The audio board (**fig. 2**) accepts inputs from various sources and sums them for output to the decoder, transmitter, phone line, and logging tape. U2 is arranged in the summing-amplifier mode and mixes several signals. The output of U2 goes through analog switch U6 (controlled by the processor) to U3. U3 sums the audio from U7 (an NE-555 oscillator) so that the phone line never hears an ID or beep. U4 drives the isolation transformer, and U5 is driven by the isolation transformer. The isolation transformer provides a dc isolated connection to the phone line. The audio signals to and from the phone line are switched by the analog switches, which are controlled by the processor. The patch is a simplex arrangement in which the audio from the phone line is cut off when a station is transmitting; this eliminates the need for any balanced network, as in a duplex patch, and it also provides a means of instantly muting the audio from the phone line. The NE-555 oscillator generates all tones (ID, courtesy beep, signaling tone). U1 is a limiting amplifier for the local microphone.

Audio level. In our repeater system we adopted a standard audio level of 2 volts p-p at 1 kHz, which corresponds to transmitter or receiver 5-kHz deviation. This may seem like a minor point, but before we

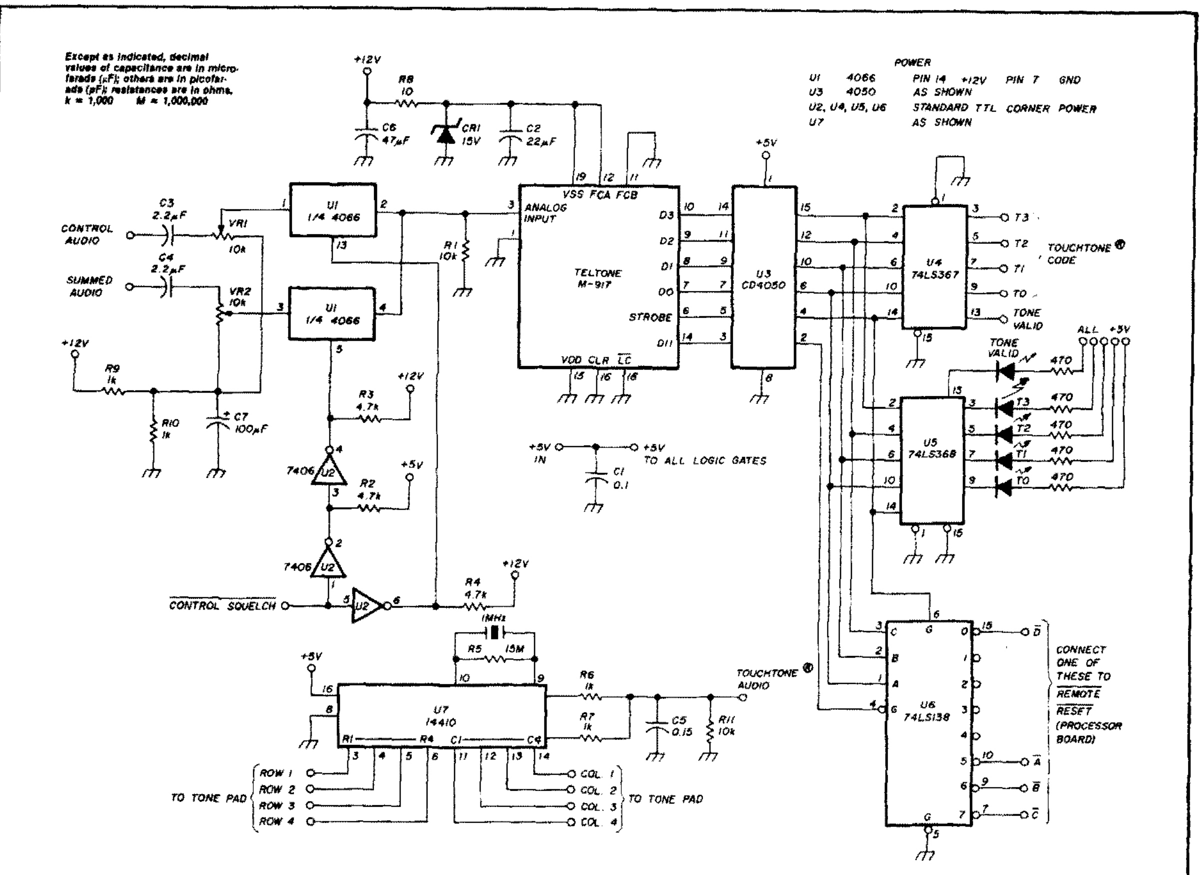

fig. 1. Dual-tone, multi-frequency (DTMF) decoder board. Decodes control tones from various sources and provides digital outputs for the processor. Also includes a DTMF encoder for the local keypad.

table 1. Front-panel LEDs, which show the decoder outputs.

	Touchtone™ LEDs T3, T2, T1, TØ
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
Ø	1010
*	1011
#	1100
A	1101
B	1110
C	1111
D	0000

adopted this approach, incompatible and unknown levels were a major source of problems. An audio level of 2 volts p-p works well with a single 12-volt supply system, allowing enough dynamic range without sacrificing noise immunity.

Other input and output signal levels can be accommodated by adjusting VR1 and VR7 and/or by changing a few resistor values (see reference 2).

Level Adjustments. Connect a 2-volt p-p, 1-kHz sine wave signal to the receiver input and adjust VR1 for 2 volts p-p at the output of U2. This sets up the basic reference for the system. VR7 may then be adjusted for proper transmitter level — in our case, 2 volts p-p. Access the autopatch and adjust VR4, while the dial tone is present, for 2 volts p-p at the output of U2.

The dial tone is usually the largest signal received from the phone line; therefore, it makes a good reference. Adjust VR3 for a Touchtone **5** having a p-p value of 2 volts at the output of U2. VR5 can best be adjusted by comparing the local pad's level on the

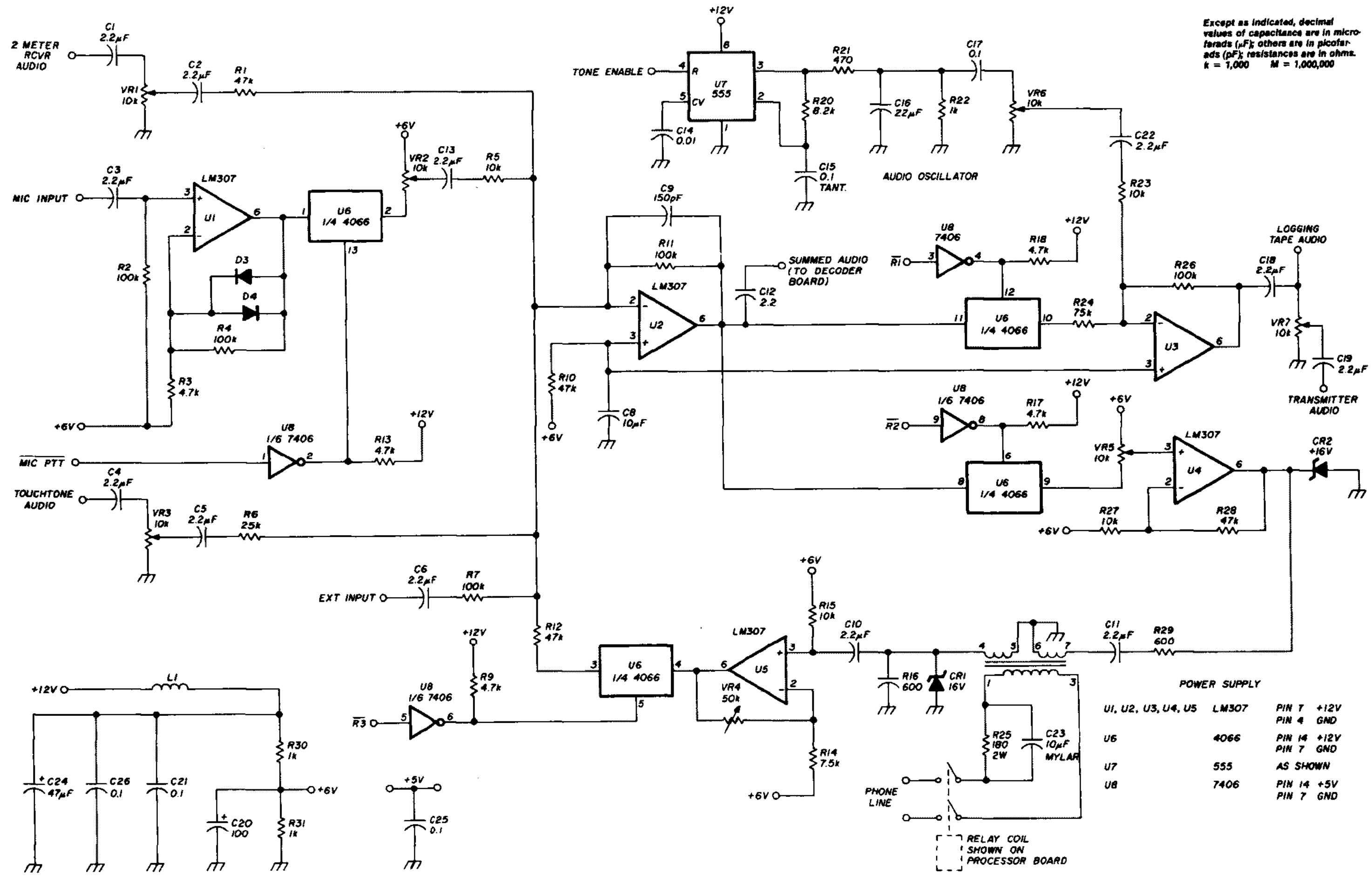

fig. 2. Audio board sums audio from several sources and supplies audio to the transmitter, logging tape, phone line and tone decoder.

phone line with a telephone Touchtone pad on the same line. The audio oscillator and microphone levels are best set by listening on the transmitter output frequency.

processor board

The processor board (**fig. 3**) performs virtually all the control functions for the repeater. The microprocessor is an Intel 8035 with onboard RAM and IO. Its clock is a precise 1 MHz, which is divided down from the 2-MHZ oscillator. The clock is connected to an *internal counter that* interrupts the processor each time the counter overflows. The processor keeps track of how many times it is interrupted; therefore it can keep track of time — this is how the real-time clock is implemented. The crystal-oscillator approach was chosen rather than using the 60-Hz line voltage as a time base since the battery backup feature is desirable.

The processor has several software timers which time various events (such as time since last ID, autopatch duration, and carrier-operated switch functions). One of the more interesting uses of the real-time clock is automatic logging of time and date in Morse code (onto the logging tape) when an autopatch call has been completed. This feature reduces the burden on the user to remembering only his call sign and getting it onto tape.

Morse code identification

The repeater's call-sign ID in Morse is performed by the processor turning the NE-555 oscillator on and off. The call sign is entered through the DIP switches by loading the shift registers, then the data are clocked in serially. The switch registers are set according to a table lookup (**table 2**). The proper code is found by locating the desired character in the table, then entering its associated binary code into the switch.

Because call signs vary in length, a means for allowing for variable length was incorporated. The processor will default to sending all six characters unless it encounters a 1 in the leftmost bit. For example, to program KBØCY, find all the letters and their associated binary codes:

K	00010100
B	00001011
Ø	00000000
C	00001100
Y	00100010

switch programming

The switches are programmed to a 1 when the switch is open. The programmed switches would be as follows for KBØCY; 00010100 00001011 00000000 00001100 00100010 10000000 The last switch has its leftmost bit set, since KBØCY does not use the sixth

table 2. Morse-code table.

character	binary	character	binary
0	00000000	I	00010010
1	00000001	J	00010011
2	00000010	K	00010100
3	00000011	L	00010101
4	00000100	M	00010110
5	00000101	N	00010111
6	00000110	O	00011000
7	00000111	P	00011001
8	00001000	Q	00011010
9	00001001	R	00011011
A	00001010	S	00011100
B	00001011	T	00011101
C	00001100	U	00011110
D	00001101	V	00011111
E	00001110	W	00100000
F	00001111	X	00100001
G	00010000	Y	00100010
H	00010001	Z	00100011

character. The software automatically adds /**R** onto the end of the callsign to indicate repeater operation.

other processor functions

The basic-instruction fetch of the processor is performed by outputting the address onto DB0-DB7 (and P20-P23), which is then latched by U2 (**fig. 3**). U3 is the EPROM that holds the program and outputs the instruction or data onto DB0-DB7. **ALE** (pin 11) *is the address latch enable. Since it is a* divided-down version of the processor clock, it makes a good test point for determining whether the processor chip is alive.

The T1 input (pin 39, U1) to the processor is one of several special-purpose input lines that are easily accessible by the software. Here it is used for the **NOT TONEVALID** signal. T0 is a similar line, and it is used for the **NOT CARRIER** signal. This input is scanned by the processor's interrupt routine, and the Carrier-Operated Switch (COS) function is performed using it. It is essentially the logical OR of all the various inputs that are used to turn on the transmitter: COS1-COS3, manual COS, Mic PTT, receiver squelch, and control squelch. The processor can be reset by powering it on, by the front-panel reset switch or, as previously mentioned, by one of the output lines from the decoder board.

The 8243 IO Expander, U4 is an 8035 family chip that provides additional IO ports easily. It is used here to drive various outputs: analog switch control lines (R1-R3), transmitter PTT line, tone enable, tape enable, patch relay, and the trigger outputs. The trigger outputs are software-controlled lines, which are intended to provide for future expansion of the repeater system. A particular control code sent to the repeater will cause one of the trigger outputs to go

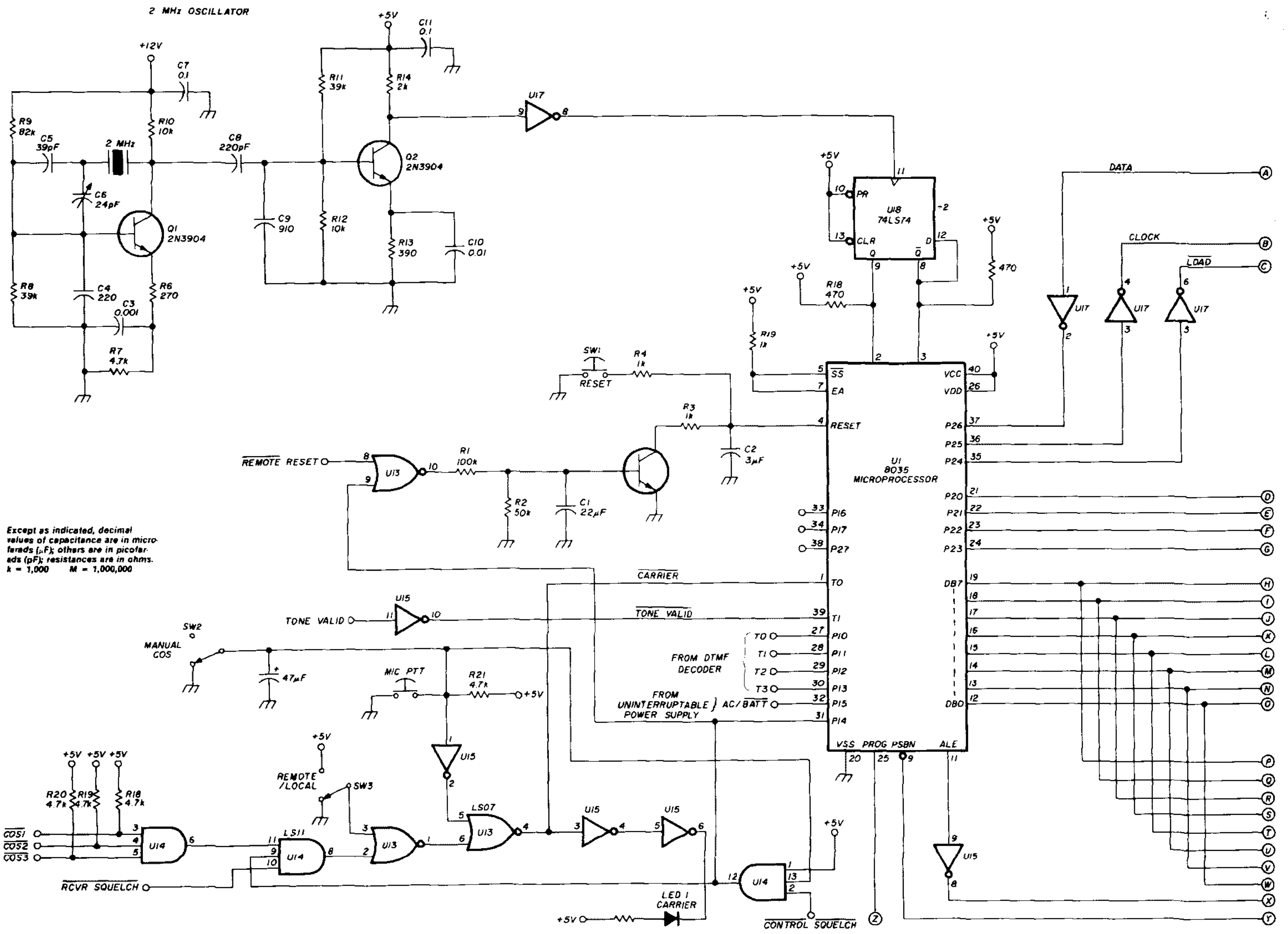

fig. 3. Processor board. Controls all functions of the repeater by monitoring the Touchtone™ decoder and various other control lines. The 2-MHz oscillator provides the time base for the software clock. The power supply is the 8035 IC (U1) as shown; all others are standard TTL corner power.

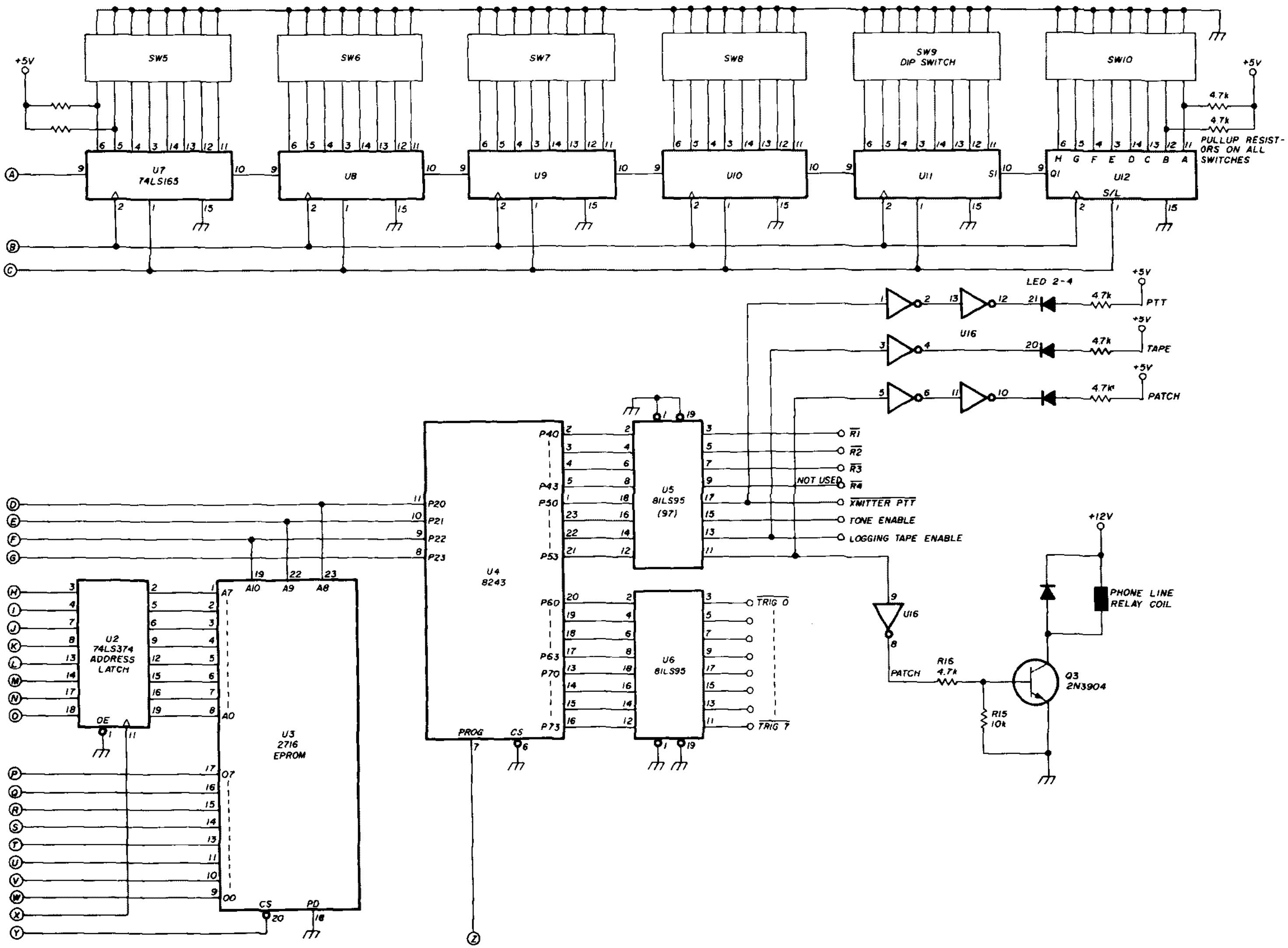

fig. 3. Processor board, continued.

low for about 60 milliseconds, thereby allowing it to trigger some external device.

Suppose an antenna relay were to be added to the system. The external device (antenna relay) would have two active low TTL compatible inputs, one to connect the relay to antenna 1 and the other to connect the relay to antenna 2. These inputs would be connected to two different trigger outputs. The appropriate antenna would be chosen by sending the control code for the desired trigger output.

P10-P17 and P20-P27 on the processor are the lines of the on-chip IO ports. Lines P10-P13 are used for entering the code from the decoder board along with the **NOT TONEVALID** signal. Line P14 is used to indicate to the processor that the current Touchtones are coming from a control source (that is, either the control receiver or the front panel). Line P15 is used to tell the processor whether ac or battery power is being used.

The manual COS switch and the Mic PTT switch are used to operate the repeater locally; that is, they simulate a carrier on the input of the receiver and cause the processor to act accordingly. The remote/local switch determines whether the repeater is in repeat mode or if it can be operated only from the front panel. The COS1, COS2, COS3 inputs were included to allow for further expansion of the system. These inputs can be used by any external device that needs to turn the transmitter on. These inputs are, logically, ORed with the receiver COS input (the processor can't tell the difference); so if the external device gets latched into the on mode, the processor will eventually time out and shut down the transmitter.

control functions

Following are some of the control functions:

1. Disable autopatch.
2. Enable 911 autopatch.
3. Enable full autopatch.
4. Program ID suffix.
5. Set time of day.
6. Set date.
7. Enable repeater.
8. Disable repeater.
9. Hardware reset.
10. Send all Morse characters.
11. Enable courtesy beep.
12. Disable coutesy beep.
13. Reset autopatch timer.

table 3. Abbreviated parts list. Most part values are not critical. Resistors are 1/4 watt unless otherwise noted; all TTL parts can be low-power Schottky (LS) or standard TTL. VRs are multi-turn trimpots.

	decoder subsection
U1	4066 CMOS switch
U2	7406 inverter (oc, or open-collector outputs)
U3	4050 CMOS buffer
U4	74LS367 TTL buffer
U5	74LS368 TTL buffer (inverting)
U6	74LS138 TTL decoder
U7	MC14410 DTMF encoder
Decoder module	Teletone M-917
	audio subsection
CR1,CR2	16 volt zener, 1 watt
CR3,CR4	silicon general-purpose diode
T1	audio transformer, 1.4:1, center-tapped primary (Western Electric transformer 2578 or similar)
U1-U5	LM307 or 741 op amp
U6	4066 CMOS switch
U7	555 timer
U8	7406 inverter (oc, or open-collector outputs)
	processor subsection
Q1-Q3	2N3904
SW5-SW10	DIP switch (8 switches, 16-pin package)
U1	Intel 8035 microprocessor
U2	74LS374D flip flop
U3	2716 EPROM
U4	Intel 8243 IO expander
U5,U6	81LS95 or 81LS97 buffer
U7-U12	74LS165 shift register
U13	74LS07 2-input NOR gate
U14	74LS11 3-input AND gate
U15,U16	74LS04 inverter
U17	74LS04 inverter
U18	74LS74 D flip-flop

user functions

All control and user codes have the following format: ***a b c**

where * represents the star on the conventional Touchtone pad and a,b,c, are digits 0-9. The following user functions have been implemented:

*195 **autopatch access**
Our repeater output frequency is 147.*195* MHz — normal autopatch access mode. The pound symbol, #, is used to shut the patch off (that is in keeping with the procedure of using * to access a patch using # to bring it down).

*911 **emergency autopatch**
This is the emergency 911-only mode described earlier.

*200 time and date
Used to transmit time and date in Morse code.

*222 ID (repeater status)
This function can be called to determine autopatch status or to read any message on the IDer.

*364 Touchtone test
This test is initiated by sending *364. After the repeater responds with the signaling tone, the user hits, in any order, all twelve keys on his pad. The repeater will respond either with the letters OK or with the characters that were not successfully received. Of course, it may be necessary to have someone else initiate the test sequence if the user's pad is totally useless.

parts

The following sources are recommended for obtaining parts (**table 3**) for the project:

Digital, Linear ICs:
Jameco Electronics
1355 Shoreway Road
Belmont, California 94002

Advanced Computer Products
P.O. Box 17329
Irvine, California 92713

Radio Shack

Touchtone Decoder:
Teletone Corporation
10801 120th Avenue N.E.
Kirkland, Washington 98033

Current price for M-917 module is $85

summary

This system was implemented on the Loveland Repeater 147.795/195 located west of Loveland, Colorado. Since the final version of this project was installed, we have experienced excellent reliability. I welcome any response to this article, and I hope it can lead to an exchange of some new ideas on applications of microprocessors and repeater-system design. I have arranged for 2716 EPROM's to be zapped with appropriate software for a nominal charge (send me a SASE for further information).

acknowledgment

Many thanks to Virgil Leenerts (W0INK), Glenn Engel (WB0HXS), Joyce Witte (KA0DEH) and the members of the Loveland Repeater Association for various forms of assistance.

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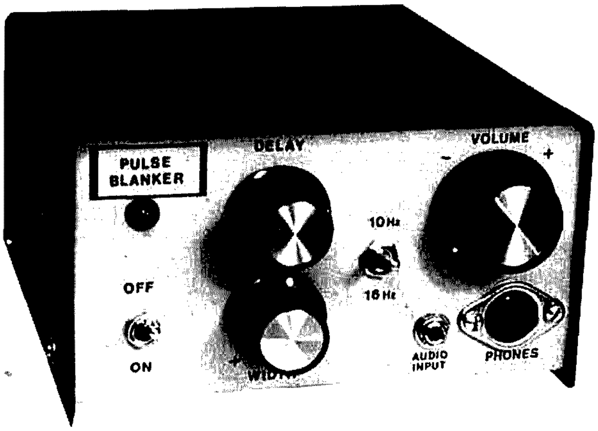

blanking the Woodpecker

part three: an audio blanker

In the first of this series of articles,[1] I pointed out that the Russian over-the-horizon (OTH) radar, or "Woodpecker," is transmitted at a very precisely defined pulse repetition frequency — usually 10 Hz. This fact leads to the possibility of locally generating a similarly precise frequency to control a noise blanker. The second article[2] investigated a circuit that could be connected to the existing noise blanker circuitry in a transceiver, making it possible to blank out the Woodpecker.

An MM5369 crystal oscillator/divider was used to generate a precise 60-Hz square wave. This was divided by six using a CD4018 CMOS IC, to give a very precise 10-Hz signal. The 10-Hz signal was processed through a series of CMOS Schmitt trigger circuits (all part of one MM74C14) to give an output pulse whose width and phase could be varied manually. By adjusting the phase of the output, one can synchronize it with the incoming Woodpecker interference. By adjusting the width of the output, one can use it to turn the noise blanker in a receiver off for precisely the duration of the Woodpecker pulses and no longer.

It is obvious that this approach is useful only when one has a receiver with a noise blanker that can be connected to the synchronous circuit. For those with receivers with either no noise blanker, or a blanker that cannot readily be connected, another approach is necessary. The circuit described in this article is an audio blanker that can be connected to the audio output of the receiver. There is therefore no need whatever to tinker with the internal workings of the set. It can be used to very good effect on receivers such as the Yaesu FRG-7.

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i-f versus audio blanking

The ideal place to blank a noise pulse in a radio receiver is early in the i-f stages. This is because the pulse becomes broadened as it passes through the narrow selectivity stages, and therefore a longer, more noticeable blank space is needed to remove it. Also, if you do the blanking in the audio stages, it may be too late to stop the noise from triggering the AGC circuit, thus muting the receiver's sensitivity. In the case of the Woodpecker, the first of these considerations is not a problem, as its pulses are already very wide (typically 15 milliseconds). The AGC swamping is a problem, however, because the Woodpecker can get very strong — at times over S9 +20. So there is a price to pay with the audio circuit, as compared with the i-f blanker. Because it is an outboard device, it does not reduce the AGC swamping caused by a really strong Woodpecker signal.

Even so, the circuit turns out to be very effective. The reason for this is that it is not only AGC swamping that reduces readability; the Woodpecker itself is at least as serious a cause of loss of intelligibility in the desired signal. This can be demonstrated by observing the problems that arise even when the Woodpecker is only operating at moderate levels. Consequently, an audio stage blanker can give considerable relief from the interference.

audio blanking

Basically, the audio blanker is an audio amplifier that can be turned on and off by a control signal. In this case, that control signal is supplied by exactly the same circuit used to control the transceiver i-f

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noise blanker, minus the final transistor.

There are a number of possible means of gating an audio amplifier. Perhaps the easiest way is to use a field-effect transistor as a switch at the input to the audio amplifier. There are two ways of using an FET as a switch: as a series-pass element or as a shunt element.

Block diagrams of audio blankers using FET switches in these ways are shown in **fig. 1**. Both depend on the fact that when an FET is switched on by the appropriate control voltage at its gate, the resistance between source and drain is quite low (a few hundred ohms). When it's in the off condition, the resistance between source and drain is very high. In this way the FET is similar to the conventional bipolar transistor. They differ, however, in that the gate of the FET presents a very high impedance to the control signal.

In the case of the series blanker, when the FET is switched off the amplifier circuit (including FET) presents a very high impedance to the incoming signal, and the output of the amplifier is low (or, at least, somewhere near the input impedance of the amplifier by itself), and the signal appears at the output of the amplifier, as required.

In the case of the shunt blanker, when the FET is switched on, it tends to short the incoming signal to ground, resulting in no output from the amplifier. When the FET is off, its high impedance means that it plays no part in the proceedings, and the amplifier does its normal job.

Both these types of FET switches can be used together if desired. I have found that in practice the series FET switch works perfectly well by itself, and it is the approach that has been followed in the circuits described in this article.

a working circuit

There are a number of points to consider when putting the above scheme into practice. First, it is essential that none of the blanking control signal gets into the audio chain, otherwise one merely substitutes a locally made series of noise pulses for the Woodpecker.

Second, one has to ensure that the audio signal one wants to hear is not tuned off and on too quickly. Otherwise the effect is to introduce switching spikes into the audio due to the sudden drop in the audio output to zero (and back up again). In other words, the control signal must turn the audio off gently.

The third consideration is the type of FET to use as switching element. I have used only junction FETs (presumably MOSFETs would work). However, one can use either P-Channel or N-channel JFETs. This choice dictates the way one applies the control signal

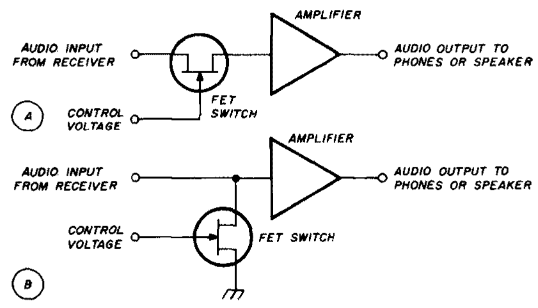

fig. 1. Basic theory behind audio blanking. An FET switch controls the audio to the main amplifier. Top diagram (A) shows series blanking; (B) shows shunt blanking.

to the FET. A negative-going control signal is necessary to turn off an N-channel FET, while a positive-going control is needed to turn off a P-channel FET.

The final decision to be made is the type of audio amplifier, its gain, and its input and output impedances.

design

In developing the audio blanker circuit, I have done a lot of "tweaking" – the circuit is more or less conventional, but the component values have been chosen as much by trial and error as any other means. Part of the trouble stems from the fact that a particular type of JFET tends to vary in its specifications from component to component, so to get a circuit to work reliably with a range of FETs takes some care. The full circuit of the audio blanker is shown in **fig. 2**.

To avoid the problem of the control signal getting into the audio chain, and also to minimize audio switching transients, it is necessary to soften the edges of the output from the digital stages that generate the control signal. In fig. **2**, U1 (an LM741) is used as a unity-gain buffer between the CMOS and the rest of the circuit. A large capacitor, C1 (33 μF), from the output of U1 to ground, effectively turns the sharp-edge digital waveform into one with sloping sides. Note that U1 is operated from a single power supply using ground as the negative bus.

Capacitor C2 and diode CR1 operate as a diode clamp, which means that the control voltage applied to the gate of the N-channel JFET, Q1, drops to about -9 volts to switch Q1 off (depending on the voltage at which the CMOS is operated – here 9 volts). The control waveforms at various points in the circuit (marked with arrows) are shown in **fig. 3**. Q1 is an MPF102, but a variety of other N-channel JFETs should work equally well. The only requirement is

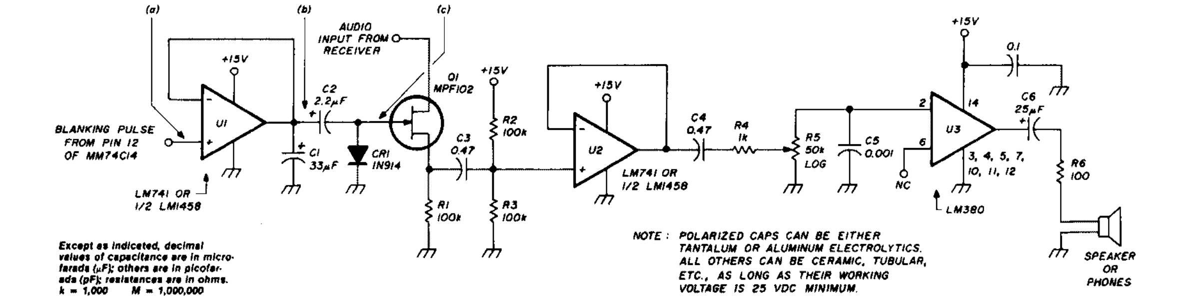

fig. 2. The audio blanker circuit. Note that the circuitry to generate the control voltage pulses was described in reference 2.

that Q1 must be switched off when the control voltage goes below about −7 volts. If necessary the CMOS voltage can be increased to ±15 volts, or U1 required to give a gain of 1. This will allow the control signal at the gate of Q1 to go to about −14 volts which should switch anything off!

JFET Q1 is in the input leg of op amp U2 (LM741). It is isolated from U2 for dc by capacitor C3. Voltage-divider resistors R2 and R3 set the dc operating point for the noninverting input of U2. U2 is arranged as a unity-gain buffer. Instead of using two LM741s, it is also possible to use one LM1458 dual op amp. However, not all types of op amps work in this circuit.

The main amplifier consists of U3, an LM380 audio amp. This is arranged in the simplest possible way (reference 3). It is isolated from the dc output level of U2 by C4. R4 limits the current drawn from U2 if R5 is set to zero. C5 and C6 in effect tailor the frequency response of the amplifier: increase C5 to cut treble, decrease C6 to cut bass. The output volume is set by R5. Depending on the sensitivity of the output speaker or phones, R6 may be omitted.

No special adjustments are necessary, but a little tweaking of the values may not go amiss. Readers may have noted that the CMOS is operated in these circuits at 9 volts, while the analog stages run on 15 volts. While these voltages can both be obtained from the same source, the object of using separate supplies is to minimize the possibility of digital spikes getting into the audio through the voltage buses.

One further important point should be noted. The control signal fed into U1 should be taken from pin 12 of the MM74C14 Schmitt trigger IC described in the previous article, *not* from the transistor or from pin 11 of the MM74C14. This is because a negative-going control signal is needed to turn off Q1.

operation

Apart from the volume-control knob on the audio blanker, the circuit is controlled in the same way as for the i-f blanker; that is, set the width control about half way, adjust the phase until the Woodpecker is

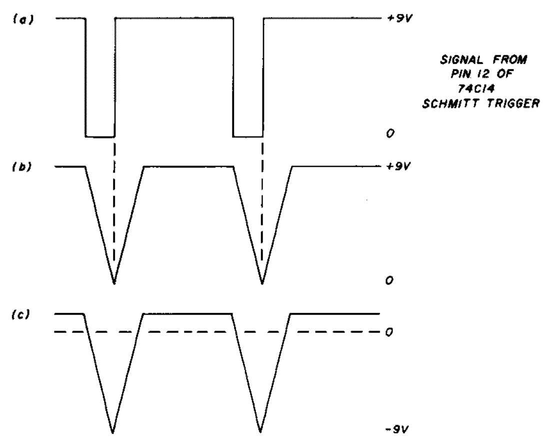

fig. 3. Waveforms to be found at various points in fig. 2.

muted best, then narrow down the width as far as possible without bringing back the interference.

conclusion

The audio blanker described here works well in curbing the Woodpecker, despite the fact that it does not remove the AGC swamping that can occur when the interference is strong. This circuit was actually developed before the i-f blanker, and I have used it on an FRG-7 for over two years. The model illustrated in the photograph is also equipped with a 10/16-Hz switch to allow the Woodpecker to be blanked when it occasionally switches to 16 Hz. Details of this circuit will be given in a future article.

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ham radio

ham radio TECHNIQUES

Bill Orr, W6SAI

Let's face it: one of the few remaining areas of experimentation available to the average Amateur is in the field of antennas. A lot of interesting antenna configurations can be built with wire, tubing, coaxial cable, and an SWR meter. On the other hand, construction of modern, digital communications equipment is outside the expertise of many Amateurs.

One of the pleasures of writing this column is getting letters from readers who are doing their own thing and experimenting with unorthodox antenna designs. I'm going to cover some of these designs in this column.

The tools required, in addition to those listed above, include a large notebook for writing down your experiments and results, and the enthusiasm to investigate and improvise. Armed with these — and plenty of caution when it comes to climbing towers and trees — any Amateur can enjoy the fruits of his labors. It's a great feeling to get an S-9 plus report on your new antenna experiment.

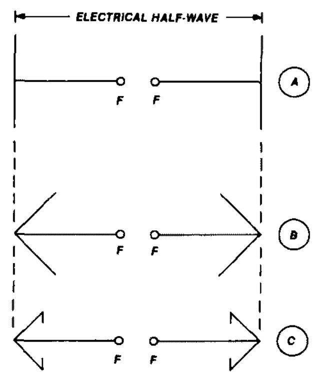

fig. 1. Evolution of the W1PLH compact dipole. (A) End-loaded dipole; (B) Loading wire folded inward; (C) Loading wires folded inward and bent.

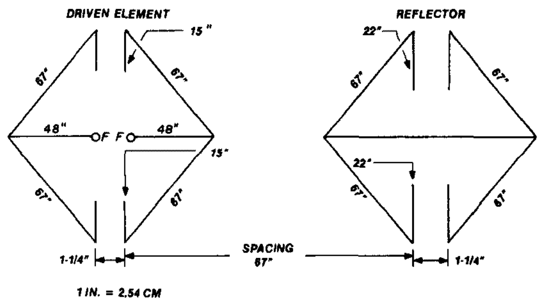

fig. 2. This looks like a quad but it is an oblique view of a Yagi! Folded and loaded elements are used in the W1PLH compact beam antenna. Elements are made of wire and strung on X-frames in the manner of a quad. A quarter-wave matching transformer and balun feed the beam at points F-F, as shown in *fig. 3*.

the W1PLH mini-beam for 15

Charlie Windslow, W1PLH, has spent a lot of time experimenting with compact antennas. His tools are a noise bridge, an SWR meter, and an old Viking Ranger II that he uses as an rf source for his experiments. (Charlie must be a pack-rat like myself. He told me he now has a collection of two noise bridges and seven SWR meters!)

His primary experiment was with a wire dipole antenna (**fig. 1**). To make a more compact antenna, he shortened the dipole and added "wings" on the end. When the wings were short and at right angles to the dipole, the input impedance and performance were comparable to that of the original dipole. Bandwith (frequency span between high SWR points on either side of the resonant frequency) was somewhat improved.

When the wings were folded inwards, as shown in the second illustration, the antenna seemed to work as well as before but both bandwidth and input impedance decreased. So far, so good.

The next step was to fold the wings

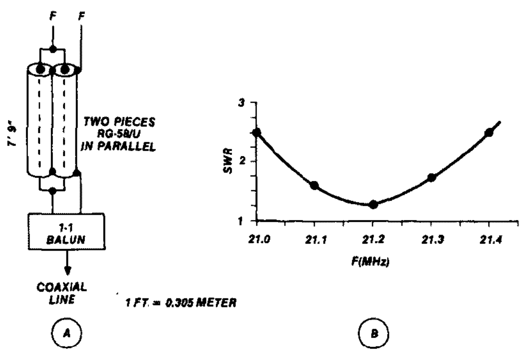

fig. 3. Quarter-wave transmission line transformer is made of parallel connected lengths of RG-58/U coax. Representative SWR curve for the W1PLH beam is shown at right.

back upon themselves until the antenna looked like the third illustration of **fig 1**. This was to be the basic element of the W1PLH Yagi (**fig. 2**). The beam is about 5 feet 7 inches on a side, with five-foot-seven-inch spacing between driven element and reflector. Design frequency is 21.2 MHz.

Input impedance of the small beam runs about 15 ohms at resonance, so Charlie made up a simple linear matching transformer made of two parallel-connected quarter-wave sections of RG-58/U in parallel (**fig. 3**). The final SWR curve of the design is also shown in **fig. 3**. Front-to-back ratio at the design frequency (middle of the 15-meter band) was approximately 12 dB. Adjusting the length of the open reflector stubs on a local signal provided optimum performance.

Power gain? Hard to tell without elaborate measuring equipment, but Charlie has worked plenty of DX with the miniature antenna and seems to be able to hold his own in competition.

the W1PLH short dipole for 75

Charlie has adapted his wing dipole for 75 meters, as shown in **fig. 4**. The overall length of the dipole is 70 feet, with 17-foot wings at each end to establish antenna resonance. The antenna at W1PLH is 25 feet high at the center, and the ends are about 15 to 20 feet above ground. The whole thing fits comfortably on a small lot. The antenna is fed with a 1-to-1 balun and about 100 feet of RG-8/U transmission line. The resonant frequency of the antenna can be adjusted by trimming the tips of the 17-foot sections. Resonance is also affected by height above ground.

Considering how low the antenna is and the loading effect of the end sections, the SWR curve across the 80-meter band is remarkably good.

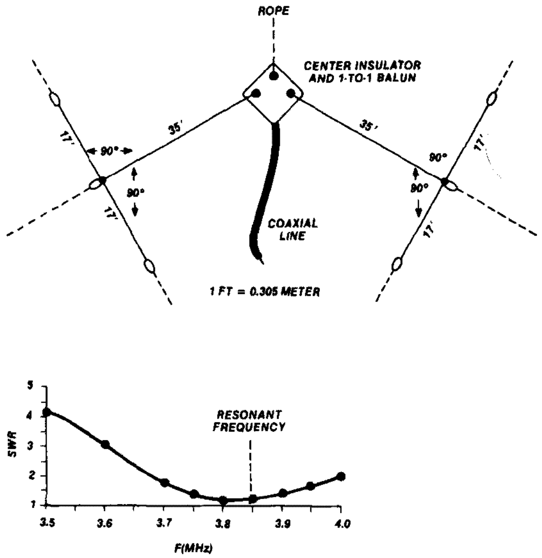

fig. 4. Oblique view of the W1PLH compact 75-meter end-loaded dipole. Joints of antenna are tied off to convenient trees and supports by insulators and rope. Overall length of antenna is only 70 feet. SWR curve is shown below.

the W2CZS inverted-V dipole for 80

Stan, W2CZS, has been an active ham since he was licensed as 1BHT in 1926. He divides his time between sailing on Barnegat Bay and working 80 meters. As so often happens, Stan ran into a space problem when he contemplated a good 80-meter antenna. Over the years he evolved a simple antenna that can operate across the whole 80-meter band with a low value of SWR. All it takes is a little physical exercise to adjust the antenna to one of three pre-chosen frequencies (**fig. 5**).

Stan's basic antenna is a folded or inverted-V. A 30-foot-high pole supports the center of the antenna and the two wires of the dipole form an angle of approximately 90 degrees. The ends of the dipole are tied to 8-foot poles with steps on them.

The main wires of the antenna are

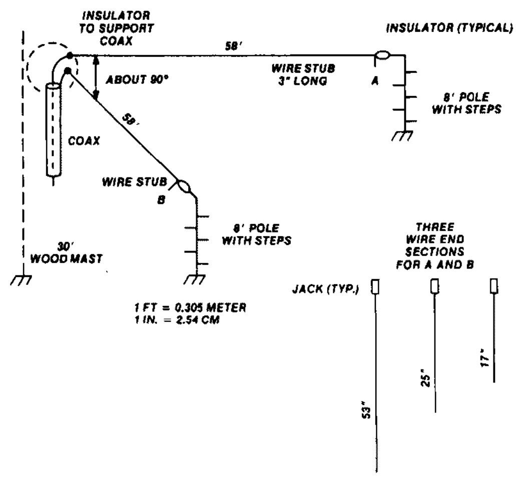

fig. 5. The compact 75/80 meter antenna at W2CZS. Stan has tip sections that he adds to each end of the V-dipole to alter length to his favorite spots in the band. It's easy to climb the 8-foot poles at the ends of the antenna and insert the tip section jacks into the wire stubs. Antenna is fed with RG-8/U coaxial line at apex.

58 feet long and are resonant at 4.0 MHz with an SWR of very close to 1:1. At the end tie-off point on each wire, a short section of wire hangs down from the insulator. To reach a lower frequency with a low value of SWR, Stan climbs each pole and clips a wire stub which hangs down from the end of the antenna. He can thus get a very low SWR on any frequency he wishes to work on the 80-meter band.

For example, two 25-inch stubs will lower the resonant frequency of the antenna to 3685 kHz and two 53-inch stubs lower the resonant frequency to 3555 kHz. Two 17-inch stubs provide low SWR at about 3800 kHz.

So there you are! Stan placed tip jacks on the ends of the antenna wires; the stubs are made of No. 12 solid wire and plug directly into the jacks. It takes but a moment to snap the wires into position.

This is a nifty antenna for those hams with a so-called "solid-state" transmitter that requires a very low value of SWR to load to full power. With just a little leg work, you can drop the SWR to near-unity at any point in the 80-meter band you choose. And the exercise is good for you!

the "all-band" antenna at W4GW

I can never get used to all these new-fangled calls. At least the ones starting with "W" sound natural. Now I find Ed Cushing, ex-W4QVJ, masquerading around as W4GW. What next?

In any event, regardless of the callsign, Ed has been around a long time and has tried many antennas. The one he recommends for high-frequency use has been around a long time, too — except that most hams have forgotten about it or have never heard of it. I guess you can call it an all-band antenna since you can tune it to any frequency in the 3.5 to 30 MHz range, including the new ham bands to be forthcoming at 10, 18, and 24 MHz. Best of all, it is only about 100 feet long (**fig. 6**). Ed says this antenna has very few compromises as it has no traps, and provides usable gain on some bands. Here's how it works:

On 80/75 meters, it is very close to a full dipole. On 40 meters it is two half-wavelengths long; on 20 meters it is close to two full-wavelengths and provides some gain over a dipole. On 15 meters it is four half-waves in phase and provides nearly 5 dB gain over a dipole. And on 10 meters, it acts as a center-fed long wire.

The two phasing stubs are made of open-wire TV "ladder line" (not ribbon), shorted at the bottom. The feedline is made of a random length of similar open-wire line, with an antenna tuner at the station end of the line. Ed notes that good quality glass insulators should be used to support the stubs, as considerable voltage occurs across these insulators on certain frequencies. If a problem exists with tuning up at any one frequency, changing the length of the feedline a foot or two will clear up the difficulty.

Ed has a bunch of trees on his property that made it impossible to put up a tower and rotary beam without removing some trees and damaging the appearance of his lot. So as a workable compromise he uses this antenna, plus a delta loop, with outstanding success on all bands!

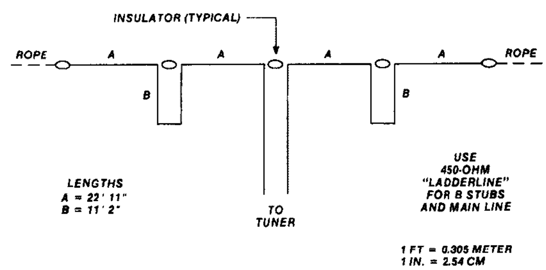

fig. 6. The 15-meter collinear array of W4GW provides nearly 5 dB gain on that band and also works on all bands from 3.5 MHz to 29.7 MHz, including the new 10, 18, and 24 MHz bands-to-be! The antenna is an "oldie but goodie."

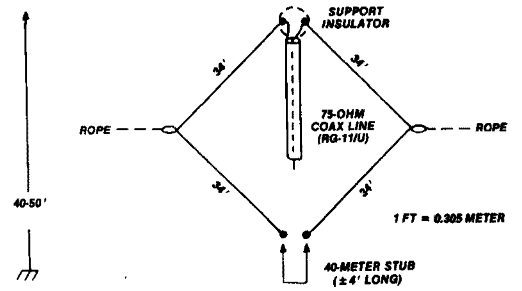

fig. 7. The two-band quad loop of W7CJB can be hung from a 40-foot-high tower. On 80 meters, the antenna operates as a dipole folded back upon itself. On 40 meters, the antenna acts as a quad loop, horizontally polarized. The bottom end of the antenna is open for 80 meters and closed with an adjustable, shorted stub for 40 meters.

the first transatlantic contact revisited

A short time ago I mentioned the first transatlantic ham QSO might have been made between the U.S.A. and England, rather than the famous contact between 1MO/1XAM and 8AB (France).

The purported QSO that brought this matter up was one reported in the August, 1931, issue of *QST* magazine; it was between 2AGB (U.S.A.) and 2JL (England) about a month before the famous QSO that has gone down in history as No. 1. Was this interesting story true, and how could it be verified? Efforts to contact either 2AGB or 2JL were futile. A friendly letter from the present holder of the call G2JL indicated he is not the original G2JL.

Now the matter seems to be finally settled by a letter from G6JP, George Jessop, the unofficial historian of the Radio Society of Great Britain and one of its former presidents.

George, an old friend of mine, looked into the matter and found that the original 2JL had been located in Crowley, Middlesex, England, and had used only a low-power spark transmitter. George talked the matter over with G2UV, who had known 2JL personally and had himself been involved in the early transatlantic test. G2UV, Bill Corsham, said that 2JL had not taken part in the tests, nor had he been capable of such a contact with his equipment.

The only other possibility was 2JF in Liverpool, who was quite active at the time and who might have made an early contact. But G2UV knew him also, and said that no such contact had taken place. So that seems to be the end of the matter. Unless more convincing evidence turns up, the original U.S.A./France contact still stands as the first transatlantic QSO. The first reception of an American Amateur in Europe was reported by 2KW in Manchester, England, who heard American 2FP just one day before the first transatlantic tests began!

And so it goes. Viewing those early days from these later days, it is remarkable that the early history of Amateur Radio is as well documented as it is. For those who are interested in the fascinating story of early Amateur Radio I recommend the book *Two Hundred Meters and Down* by Clinton B. DeSoto, ex-W1CBD, and obtainable from the American Radio Relay League, Newington, Connecticut 06111. It is a great story about the "roots" of Amateur Radio!

the 80-40 meter loop antenna of W7CJB

To wrap up this column, let's look at the simple two-band loop that is used at W7CJB. Old timers will recognize this, but it may be a new idea to some of our recently licensed friends (see **fig. 7**). Basically, it is a loop dipole that is opened opposite the feed point for 80-meter operation. This point is jumpered for 40-meter operation. The antenna is 34 feet on a side and is fed at the apex with 75-ohm coaxial line (RG-11/U). A good (but not exact) impedance match is obtained on each band and the antenna loads properly with most transmitters having a nominal 50-ohm antenna preference.

The loop can be hung vertically from a tower, or tilted outward from the tower if height is a problem. It has been used with towers as short as 40 feet.

With the bottom of the loop closed, the bottom legs are trimmed to provide resonance in the 40-meter band. The loop is then opened and resonance checked in the 80-meter band. You can temporarily fold back equal lengths of wire in the lower legs to find resonance at 3.9 MHz; you can then clip this off and use a four foot stub to short the antenna for 40-meter operation. The clip-on stub is a quick method of band changing, and costs next to nothing.

last call!

I have a few reprints of my series of articles entitled "Design Consideration for Linear Amplifiers." This series ran in *ham radio* in 1979, and it's a compendium of engineering information for those interested in building high-frequency linear amplifiers. A copy is free (except for postage).

Write to me at Varian EIMAC, 301 Industrial Way, San Carlos, California 94070, and ask for a copy. Please send three 20-cent stamps to cover postage (or whatever amount first-class mail will cost by the time this issue of HR reaches you!). Overseas readers, please include four IRCs with your request.

Note: Interested in build-it-yourself antennas? Send for *The Radio Amateur Antenna Handbook* by W6SAI and W2LX. It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $6.95 plus $1.00 to cover shipping and handling.

ham radio

performance capability of active mixers

Part one: Basic mixer characteristics and interfering effects during the signal-handling process

Depending upon the application, a large variety of circuits are used in passive and active mixers. It appears that mixers have a figure of merit expressed in the form of intermodulation distortion performance (intercept points of the order *1, 2, 3...n*), suppression of harmonics and isolation, cut-off frequency, and local oscillator drive.

The simple mixer consisting of one diode is generally found only in small pocket radios. Any high-performance receiver or synthesizer application requiring mixers will make use of the harmonic-canceling effect of double-balanced mixers in a lattice configuration. Passive mixers have used either vacuum diodes, germanium diodes, silicon diodes or hot-carrier diodes. Two of the basic requirements for these mixers are perfect match of the transformers and perfect match of the diodes. As the diodes are used in what is called "large-signal application," the same nonlinear performance of the transfer characteristic that is responsible for mixing generates harmonics of the input frequency and of the local oscillator frequency; these may appear at the output of the double-balanced mixer if it is not carefully balanced. Perfect matching will prevent even-order harmonics from appearing at the output, and the so-called linear operation of the mixer, where the local oscillator does not drive the nonlinear device, will prevent excessive harmonic generation as such. Theoretically, mixers can be driven with square waves — another method of reducing harmonic combinations at the output.

While all passive mixers have losses, active mixers appear attractive because of their potential for showing gain. Using active devices as mixers, we must consider three different applications:

1. Additive mixers.

2. Multiplicative mixers.

3. Switching operation, where the active device is used as a switch and operated without dc voltage.

From a device point of view, we have three different possibilities:

1. Bipolar transistors in mixers.

2. Square-law-characteristic devices: junction field-

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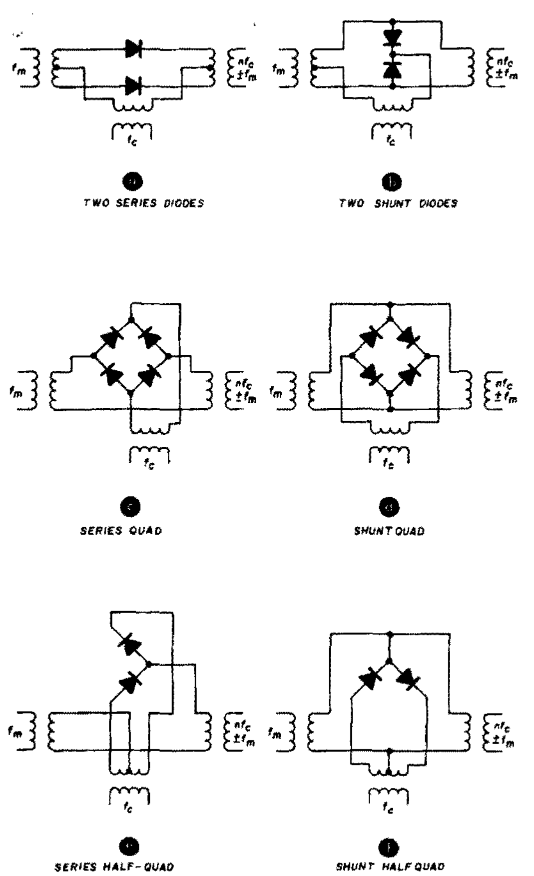

fig. 1. Series and shunt type mixers.

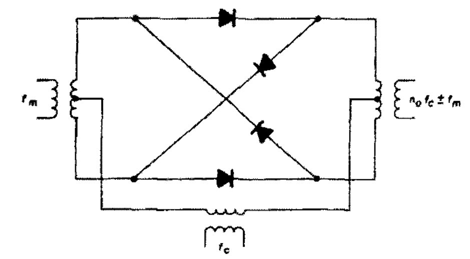

fig. 2. Standard-level double-balanced mixer.

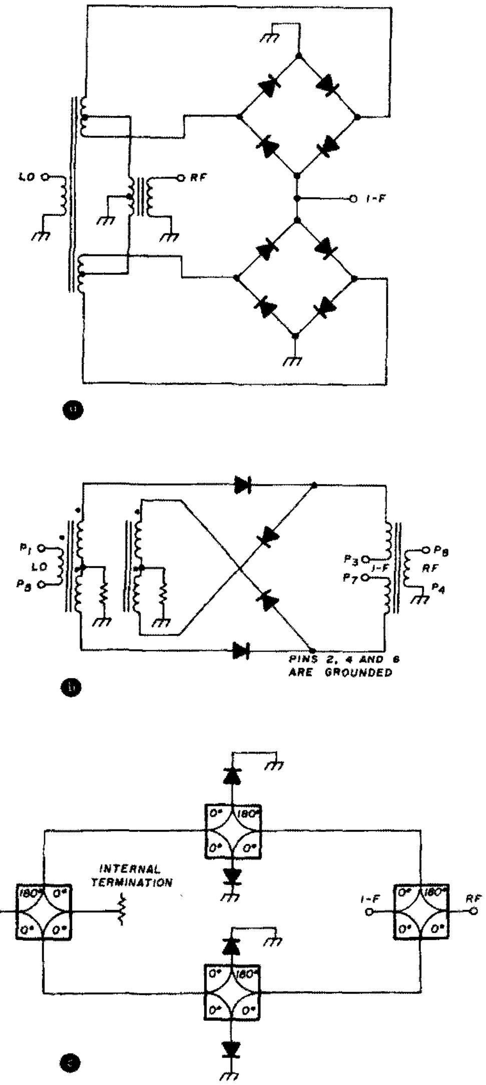

fig. 3. High-level double-balanced mixers, A and B, and termination-insensitive mixer, C.

effect transistors, MOS field-effect transistors, and enhancement field-effect transistors (VMOS).

3. Dual gate MOSFETS, or IC-type mixers.

This article shows some of the advantages, disadvantages, and high signal effects found in active mixers, their possible cures and trends. I should mention now that, for reasons explained very carefully in this article, either a) the passive mixer with special diode-ring configurations, or b) the field-effect transistors in a quad configuration used as a switch with no amplification is the ultimate choice for high performance. It has been shown experimentally that intercept points of +40 dBm are possible using active devices in passive mixers with about 6-dB loss and 6-dB noise figure.

Active mixers like synthesizers can be used in a constant-amplitude environment; however, in the more hostile environment typical of receiver applica-

tions, passive mixers are still less expensive, more reliable, and offer superior performance.

mixer basics

Mixing occurs in any nonlinear device where the V/I curve deviates from a straight line if and when two or more signals are applied to such a device. The ideal and so-called linear mixer is a square-law device, like a field-effect transistor, with the transfer characteristic

$$i_D = I_{DSS}\left(I - \frac{V_{GS}}{V_p}\right)^2 \quad (1)$$

The transconductance is defined as the first derivative of d_i/d_v, and therefore

$$GM = \frac{2I_{DSS}}{V_p^2}(V_p - V_{GS}) \quad (2)$$

This is called linear mixing. It can be seen that the transconductance, GM, is a linear function of the gate source voltage, V_{GS}.

Neglecting any nonlinear effects such as might be found in MOS field-effect transistors, or any reverse biasing effects as found *in junction* field-effect transistors, or inability to follow high-frequency input voltage as found in VMOS transistors, the square-law characteristic will generate only the second harmonic of the input and local-oscillator signal. A perfect match in a double-balanced configuration would cancel this.

This absence of a third-order term would theoretically prevent any odd-order intermodulation distortion product from occurring. Such a square-law characteristic is found in field-effect transistors as mentioned; and for small signals, silicon or hot-carrier diodes exhibit the same square-law characteristic.

A number of configurations are known using diodes in bridges to minimize harmonics at the output, and **figs. 1A** through **1F** show the series and shunt combination in which either two or four diodes can be used.

As shown in the literature,[1] even with ideal diodes of zero forward resistance and infinite reverse resistance, the conversion loss of either the series or shunt modulator is $20 \times \log(\pi) = (9.9\ dB)$. Practical modulators will have higher losses than this, as the diodes are not ideal.

Fig. 2 shows the ring or lattice double-balanced modulator as frequently used, and **fig. 3** shows the latest two most important derivatives of the double-balanced mixer, the two ring configuration and the termination-insensitive mixer. It has been explained very carefully in the literature[2] that all passive mixers are highly sensitive to changes in termination. The reason for this is that the non-zeroing effect of reactive currents at the output generates reflections inside the bridge and, therefore, causes distortion.

Double-balanced mixers are traditionally offered in 50-ohm input and output impedances and, as most rf applications now use 50 ohms, this is very convenient. It is extremely important that the input and output ports are balanced, and for this reason balun transmission-line transformers are used at these terminals. By using different wire sizes, the transmission-line transformer impedance can be changed to a different value. Additional external transformers can shift the impedance to almost any value required. **Fig. 4** shows a mixer with additional balancing at input and output. (The assumption that the 4:1 or 1:4 transformer provides ideal matching from unbalanced to balanced input or output is not necessarily true.) These discussions apply also to active mixers, as I have stressed that the input and output ports must be balanced to suppress harmonics.

The best passive mixers show an output intercept point of +30 to +35 dBm, use up to 64 monolithic diodes, and require up to +23 dBm of local-oscillator injection. A push-pull configuration of two balanced mixers can show isolation of up to +60 dB over an extremely wide frequency range; the insertion loss is in the vicinity of 5.5 dB and can be operated from 10

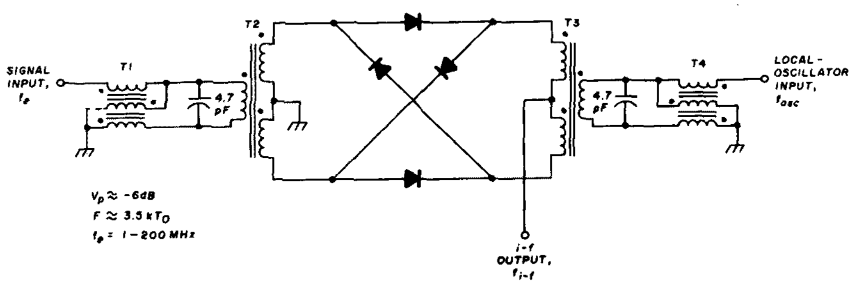

fig. 4. Practical circuit for a double-balanced mixer, including input and output balancing transformers.

kHz to several GHz, depending upon the transformers.

In the case of an active device, taking into consideration the linearities of the diode or active mixer, we can use the method of Fourier expansion to obtain the harmonic component of the local-oscillator pulse train of $0.2 = 2\pi/\omega$.

Fig. 5 shows the train of sine-wave tip current pulses if a sine wave, the local-oscillator signal, drives the slope of G that represents the transfer characteristic. The resulting output can be used to determine the *time average conductance* of the device as a function of the conducting angle. To do this, we use the Fourier cosine expansion

$$f(t) = a_0 + a_1 \cos \omega t + a_2 \cos 2\omega t + \ldots$$

$$= a_0 + \sum_{n=1}^{\infty} a_n \cos n\omega t \qquad (3)$$

where

$$a_0 = \frac{1}{T} \int_{-T/2}^{T/2} f(t)\, dt \qquad (4)$$

and

$$a_n = \frac{2}{T} \int_{-T/2}^{T/2} f(t) \cos n\omega t\, dt \qquad (5)$$

By defining $\theta = \omega t$ and integrating over $d\theta$, we obtain

$$a_0 = \frac{1}{\pi} \int_0^{\pi} f\left(\frac{\theta}{\omega}\right) d\theta \qquad (6)$$

and

$$a_n = \frac{2}{\pi} \int_0^{\pi} f\left(\frac{\theta}{\omega}\right) \cos n\theta\, d\theta \qquad (7)$$

From **fig. 5** it can be shown that the fundamental component

$$I_1 = \frac{2}{\pi} \int_0^{\phi} G(V_1 \cos \theta - V_x) \cos \theta d\theta$$

$$= \frac{2G}{\pi} \left(\frac{V_1 \phi}{2} + \frac{V_1 \sin 2\phi}{4} - V_x \sin \phi \right)$$

$$= \frac{I_p}{\pi} \left(\frac{\phi - \cos \phi \sin \phi}{1 - \cos \phi} \right) \qquad (8)$$

In a similar way, we obtain

$$I_0 = \frac{I_p}{\pi} \left(\frac{\sin \phi - \phi \cos \phi}{1 - \cos \phi} \right) \qquad (9)$$

and

$$I_n = \frac{2I_p \cos \phi \sin n\phi - n \sin \phi \cos n\phi}{\pi n(n^2 - 1)(1 - \cos \phi)}, n \geq 2 \qquad (10)$$

As explained in my previous paper,[3] **fig. 5** can be drawn by plotting the normalized output, normalized voltage gain, and normalized mixing transconductance, S, as a function of normalized oscillator voltage. From **fig. 6**, we would see a practical value for $X = 0.75$, and we get a mixing (or conversion) transconductance $G_m = 0.56 \bullet G'_M = 1.25\ mS$ for a 2N3822 field-effect transistor. For a higher-order transfer characteristic, the approach would be the same, and the equation for I as a function of V would change.

As mentioned previously, we have three types of mixing:

Additive mixing. Additive mixing is based upon the

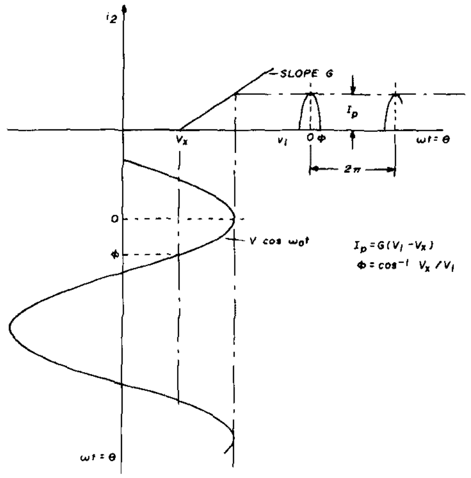

fig. 5. **Sine-wave tips representing the time variable transconductance of a square-wave transfer-characteristic device.**

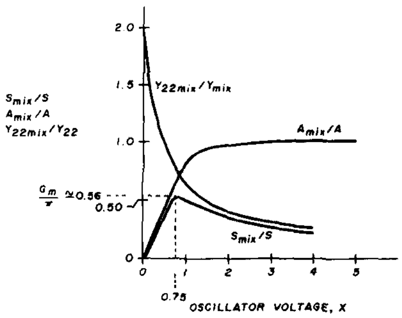

fig. 6. Normalized voltage gain, output impedance and mixing transconductance, S, for the FET.

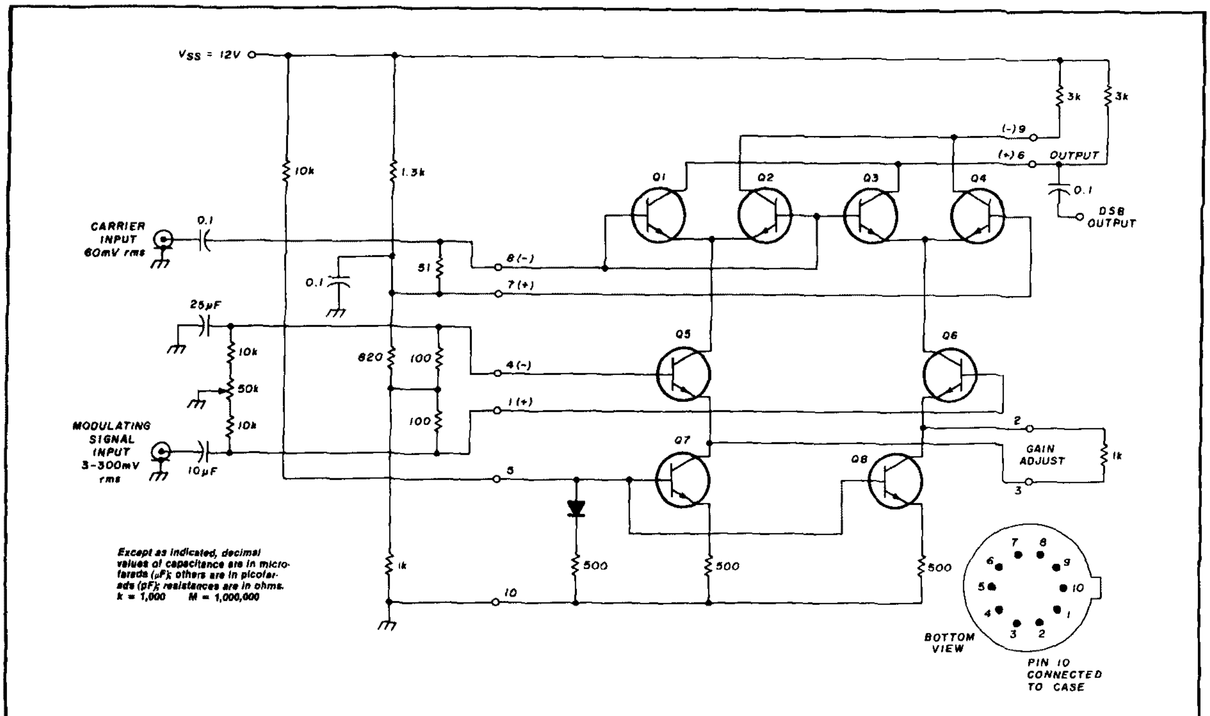

fig. 7. Active mixer using the Motorola MC1596.

fact that the two components $v_1(t) + v_2(t)$ can be rewritten in the form

$$V = V_1 \cos \omega_1 t + V_2 \cos \omega_2 t \qquad (11)$$

The expansion of this leads to the product

$$C(t) = \{\cos (A - B)t + \cos (A + B)t\}$$

Additive mixing would occur where the two signals are being fed in series. All field-effect and bipolar transistor mixers use the additive principle regardless of whether the local-oscillator signal is applied together with the rf signal to the same *electrode* (gate, base, source, or emitter) or to different electrodes.

Multiplicative mixing. Only in the case of a) a dual-gate MOSFET, and b) a differential amplifier with a constant-current source, can we use the term *multiplicative mixing*. However, the net result remains the same. The advantage in using multiplicative mixers is that isolation exists between the two ports, which means that very little or no interaction occurs between the rf and the local-oscillator port.

Fig. 7 shows a recommended circuit for the Motorola MC1596 integrated circuit, which is the basis for the Plessey mixer type SL6440 shown in its test circuit, **fig. 8**. Plessey reports an intercept point in the vicinity of +30 dBm, about 0-dB gain, and roughly an 11-dB noise figure.

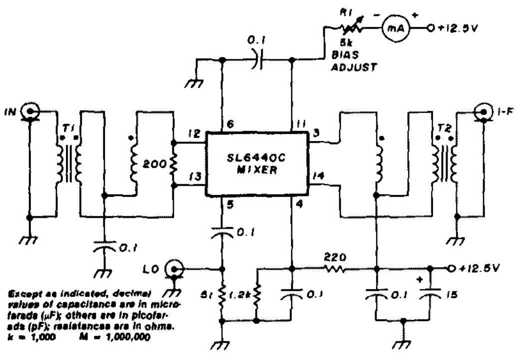

fig. 8. Recommended test circuit for the SL6440 active double-balanced mixer.

Mixing by switching. In the case of the double-balanced mixer using diodes, the *diodes act as a switch*. These switches must be fast enough to follow the local oscillator; therefore, hot-carrier diodes are used for high-frequency operation. Because of the switching, the input and output impedances are reflected at the output and input, and the mixer becomes transparent. The insertion loss is primarily determined by the fact that the sum and difference of the two sig-

nals is at the output, and only one of them is the wanted signal. If the input voltage is divided into two output voltages, we must have 3-dB loss. The additional losses occur from the fact that the diodes have series resistors, which are responsible for these losses. The amount of resistive loss is in the vicinity of 2 to 3 percent due to the 1-ohm resistance the diodes exhibit under switched-on conditions. Ideally, this type of mixing does *not* depend upon any transfer characteristic, and we will see later that if this type of operation is duplicated with active devices, we will obtain the best possible performance.

signal handling

The characteristic of the nonlinear device again can be expanded in the form:

$$\begin{aligned} g_m &= a_{01} \\ &+ \frac{a_{02}}{2!} v + \frac{a_{03}}{3!} v^2 + \frac{a_{04}}{4!} v^3 + \ldots \\ &+ \left(a_{11} + \frac{a_{12}}{2!} v + \frac{a_{13}}{3!} v^2 + \frac{a_{14}}{4!} v^3 + \ldots \right) \cos \omega_0 t \\ &+ \left(a_{21} + \frac{a_{22}}{2!} v + \frac{a_{23}}{3!} v^2 + \frac{a_{24}}{4!} v^3 + \ldots \right) \cos 2\omega_0 t \\ &+ \ldots \end{aligned} \tag{12}$$

The following significant interfering effects can be distinguished:

a. Hum modulation, expressed by:

$$m_u \approx \frac{a_{12}}{a_{11}} V_u \tag{13}$$

where m_u = undesired modulation of carrier, and
V_u = = amplitude of the a-f voltage causing modulation.

b. Variation of the modulation depth, expressed by:

$$M \approx \frac{\Delta m}{m} = \frac{1}{4} \left(\frac{a_{13}}{a_{11}} \right) V_1^2 \tag{14}$$

where V_1 = average amplitude of desired signal.

c. Modulation distortion, expressed by

$$D_2 \approx \frac{3}{16} \left(\frac{a_{13}}{a_{11}} \right) V_1^2 \tag{15}$$

where V_1 = average amplitude of desired signal.

d. Cross-modulation, expressed by

$$K = \frac{m_k}{m} \approx \frac{1}{2} \left(\frac{a_{13}}{a_{11}} \right) V_u^2 \tag{16}$$

where V_u = average amplitude of undesired signal.

e. Spurious responses at $n_1 = 1, n_0 = x$, expressed by

$$\frac{V_1}{V_u(x,1)} \approx \frac{a_{x1}}{a_{11}} \tag{17}$$

where V_1 = average amplitude of desired signal, and $V_u(x,1)$ = amplitude of spurious signal giving the same output as the desired *signal*.

f. Spurious responses at $n_1 = 2, n_0 = x$, expressed by

$$\frac{V_1}{V_u(x,2)} \approx \frac{a_{x1}}{4a_{11}} V_u(x,2) \tag{18}$$

where V_1 = average amplitude of desired signal, and $V_u(x,2)$ = amplitude of spurious signal giving the same output as the desired signal.

The coefficients of eq. 12 depend on the $i_2 = f(v_1,v_0)$ characteristics of the mixer. If, for example, the pseudo-static current I_2 of an additive mixer is shown as a power series,

$$\begin{aligned} I_2 = I_2(0) + pV + qV^2 + rV^3 + sV^4 + tV^5 \\ + uV^6 + \ldots \end{aligned}$$

then for $V \rightarrow v + V_0 \cos \omega_0 t$, $I_2 \rightarrow i_2$, and since $i_2 - I_2(0) = g_m(t)v$,

$$a_{01} \approx p + 3/2rV_0^2 + \ldots \tag{19}$$

$$\frac{a_{02}}{2} \approx q + 3sV_0^2 + \ldots \tag{20}$$

$$\frac{a_{03}}{6} \approx r + 5tV_0^2 + \ldots \tag{21}$$

$$a_{11} \approx 2qV_0 = 3sV_0^3 + \ldots \tag{22}$$

$$\frac{a_{12}}{2} \approx 3rV_0 + 15/2tV_0^3 + \ldots \tag{23}$$

$$\frac{a_{13}}{6} \approx 4sV_0 + 15uV_0^3 + \ldots \tag{24}$$

$$a_{21} \approx 3/2rV_0^2 + 5/2tV_0^4 + \ldots \tag{25}$$

$$\frac{a_{22}}{2} \approx 3sV_0^2 + 15/2uV_0^4 + \ldots \tag{26}$$

The coefficients depend on the bias point. Using theoretical characteristics of the various mixers often leads to inaccurate results, because the influence of parasitic effects may be considerable.

The final part of this article discusses some practical circuits, including an active mixer with perfect termination, a passive double-balanced mixer with a termination stage, and a passive mixer with active devices. Finally, some suggestions are given for testing and analyzing mixer characteristics.

references

1. D.G. Tucker, *Modulators and Frequency-Changers*, Mc Donald & Co., Publishers Ltd., London, 1953, pages 72-75.
2. Ulrich L. Rohde, DJ2LR, "Optimum Design for High-Frequency Communications Receivers," *ham radio*, October, 1976.
3. Ulrich L. Rohde, DJ2LR, "The Field-Effect Transistor at V.H.F.," *Wireless World*, January, 1966, page 2.

ham radio

comments

(Continued from page 8)

lying SWR meters

Dear HR:

In the October, 1981, article on SWR meters, no mention was made of a serious fault in this family of meters. Lying SWR meters have been a major source of the confusion about SWR.

This meter, with slight variations, has appeared in the literature over a number of years. It has always had one fault: It gives correct indications only at one setting of R1 and R2, because the diodes are non-linear at low currents. If the pots are set at the low-resistance end, the meter will give optimistic indications of low SWRs. The scale the author shows in **fig. 3** can be correct at only one setting of the pots — and he does not tell how they were set when he made the scale.

The meter will give excellent results, though, if it is calibrated at one setting of the pots and the pots are left at that setting. Since the output level of almost all modern transceivers is adjustable over a wide range, it is not necessary to disturb the pots.

The meter is particularly good for permanent connection in the antenna line of a station. Moreover it is a better relative rf output indicator than the ones included in most transceivers.

Donald E. Johansson, WA4UPN
Tobaccoville, North Carolina

In response to the letter from Donald E. Johansson, WA4UPN, I would like to take this opportunity to make a few comments about the subject material and the general intent of the article. The article was intended to be a home project that could be built by an Amateur without extensive experience or lab-type test facilities. It was in no way claimed to be a state-of-the-art device but rather a handy device that is relative in nature rather than absolute.

As to the shortcomings of the unit, it, like many of its predecessors both commercial and homebrew, is not perfectly linear. This is because of the nature of the diodes, as discussed by Mr. Johansson. This in no way, however, reduces the use of such a device for Amateur applications.

As to the scale used for the reflected reading, it was developed with the aid of resistive loads at 21 MHz and 90 watts output power. This level was chosen to approximate today's transceivers. Performance of the completed units, two of which were built to insure that the unit could be duplicated from the manuscript, approximated that of a commercial unit of similar design.

Over the years there have been many articles published on the subject of SWR meters and their use, and many discussions as to their value to the Amateur. Arguments have been offered, both pro and con, as to the use of such meters and to what their readings really indicate about radiated power. In the course of this construction article I tried to avoid any empirical discussion of this nature and did not delve into the theory of transmission lines or antenna systems. The SWR meter article is strictly a weekend construction project, not a course on waves and fields.

My thanks to Mr. Johansson for his interest in the article and for pointing out the fact that this — and other meters of this type — should not be thought of as lab standards.

Ken Powell, WB6AFT
Boca Raton, Florida

on-air tune-up

Dear HR:

I would like to take exception to a statement made by Bob Locher, W9KNI, in his reply to a letter by Fred Streib, W6NA, in the September *ham radio*. Bob says that it is impossible to tune up a rig without putting the full signal from the final out to the antenna and thus on the air. Actually, it is easy to knock that signal down by 45 dB by using equipment that has been described in the ham magazines. All that is required is a transmatch (or in my case, a simple homebrew T-network tuner), a dummy load (which most hams already own, or should) and the K4KI tune-up bridge which was described in the December, 1979, *QST*. If Bob hasn't read this article, I would like to suggest that he does. I would likewise suggest that anyone else desiring to cut down on the unnecessary tune-up QRM on the bands read it.

The construction technique used by K4KI leaves something to be desired in the amount of radiated signal during tune-up. My technique was to use two Heath coaxial switches instead of a simple toggle switch to switch the bridge in and out of the line. I also used the toroid from a Heath HM-102 SWR meter (spare parts cost $2.00) for the bridge coupler element.

The use of this equipment forces the final to see an exact 50 ohm load even though the antenna itself may not be an exact match. Thus loading is exactly the same on the antenna as on the dummy load.

To me throwing two additional switches and adjusting two more controls is worth the effort, when I know that my tuning-up signal is 45 dB lower than it would be if I were tuning up on the air.

Wayne H. Sandford, Jr., K3EQ
Warrington, Pennsylvania

better than ever

Dear HR:

I didn't know if I'd like your magazine or not but I do — it's as good as *Ham Radio Horizons* ever was. I enjoy the fact that you've made it more technical than HRH but not so much that you need an EE degree to understand it. I really hope you continue along the lines you've established.

Paul E. Regan
Rye, Colorado

simple tests for TTL ICs

Checking 7400-series devices for homebrewing projects

The TTL **IC tester described** in the August, 1976, issue of *ham radio* is, I believe, a much needed test instrument for builders of modern equipment. Although suppliers of ICs guarantee the devices they sell — with promises of replacing them — the implication is that the buyer must test them. The low prices quoted indicate that something less than prime quality is being offered; thus the probability of there being some faulty units is high. Even supposedly prime-quality devices have been found to be faulty. Recently I bought two 7400s advertised as prime quality; each had one faulty gate!

The TTL tester described in *ham radio* is fine for someone building a circuit using fifty or more TTLs. However, I believe the person lured into building a circuit using only a few ICs, because of its simplicity and promised performance, needs a simple method of testing ICs. (Keyers and small counters are examples of such projects.)

It is my opinion that an elaborate tester is unnecessary, especially for homebrew projects using a small number of ICs of a few types. When the number of ICs reaches 50 or 100 or more, then a more elaborate unit, aimed at ease and speed of operation, is justified.

Thus, I'm submitting this description of a simple method of testing TTL ICs. All the necessary gear is usually available in most Amateur stations — particularly those of homebrewers. A voltmeter, 5-volt power supply, six or so clipleads with miniature alligator clips, and a resistor are all you need to check .nost TTL integrated circuits. Although not absolutely necessary, a DIP socket mounted in a small PC or perf board is helpful in handling the IC and its connections.

NAND gates

To check NAND gates such as the 7400, 7410, 7420, and 7430, connect +5V to pin 14, ground to pin 7, and a voltmeter to one of the gate outputs (pin 3, for instance on the 7400), (see **fig. 1**). The voltmeter should read, typically, less than 0.22 volt. To

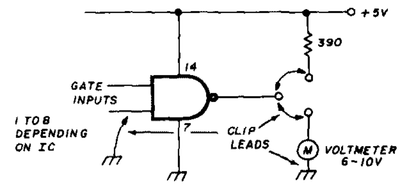

fig. 1. Test setup for checking NAND gates.

check fanout capability, connect a 390-ohm resistor between +5V and the gate output under observation. Voltage should read 0.4 volt or less (typically 0.22V). Check each gate output in this manner; that is, pins 3, 6, 8, and 11 on the 7400; pins 6, 8, and 12 on the 7410; and similarly on other NAND-gate ICs.

Remove the 390-ohm resistor, and with the voltmeter on the gate output, ground inputs of that particular gate, one at a time. Corresponding gate output voltage should increase to at least 2.4 volts as each input is grounded. Typical voltage is 3.3 volts; however, some units may show almost 4 volts. These are OK. Repeat this test on all gate outputs.

D-type edge-triggered flip-flops, 7474, are checked similarly (**fig. 2**). After connecting +5V and ground,

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connect the voltmeter to the Q output, pin 5 (or pin 9). With clipleads ground DATA pin 2 (or 12); also ground the CLOCK line, pin 3 (or 11). Now, ground PRESET pin 4 (or 10), momentarily. The Q output should increase to, and remain at least at, 2.4 volts — typically 3.5 volts. Ground CLEAR pin 1 (or 13) momentarily. The Q output should decrease to, and remain at, 0.22 volts (typical). Moving the ground (cliplead) alternately from PRESET to CLEAR will cause the voltage at Q to change from high (3.5V) to low (0.22V). With the voltage at Q at a low state (0.22V), remove the ground clip from DATA pin 2 (or 12). Then *momentarily remove* ground from the CLOCK line, pin 3 (or 11). The Q output should increase to at least 2.4 volts.

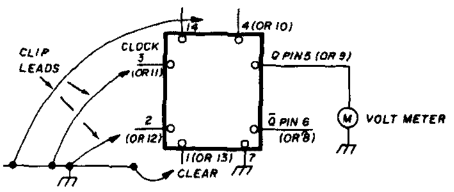

fig. 2. Checking edge-triggered flip-flops.

Restore the ground on the DATA line; momentarily remove the ground from the CLOCK line. The Q output should decrease to less than 0.4 volt. Momentary removal of the ground from the CLOCK line is a simple (and crude?) way to produce a positive-going clock pulse. An ordinary toggle switch, or, better yet, a spring-return switch instead of the cliplead would make the task easier, especially if many units must be tested.

Testing J-K flip-flops such as the 7470, 7472, 7473, 7476 and the decade counter, 7490, requires a little more equipment. The simple method of creating a clock pulse, described above, would give confusing results because of contact bounce. Thus, a no-bounce clock pulse is required. A simple way to achieve such a clock pulse employs a 7400 connected as a latch with spring-return switch operating the latch (fig. 3). A grounded cliplead could be used instead of the switch. Normally it would be on pin 5, then moved momentarily to pin 1 and back to pin 5. (An extra socket is required for the clock generator.)

The 7470 and 7472 may be checked in the same socket used for the 7474, 7400, and 7410. However, the 7473 and 7490 have terminals other than pin 14 for 5V and pin 7 for ground; and the 7476 requires a sixteen-pin socket. If testing is limited to ICs in the fourteen-pin DIP package, then three sockets allow

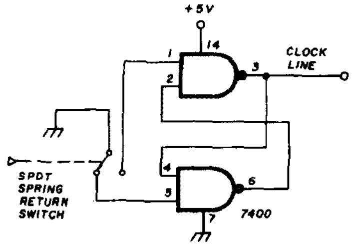

fig. 3. Method for testing J-K flip-flops. A no-bounce clock pulse is obtained by using a spring-return switch to operate the latch.

quite an array of ICs to be tested by this simple method. The 7473 uses pin 4 for 5V and pin 11 for ground, while for the 7490, 5V connects to pin 5, and ground connects to pin 10. To avoid adding a fourth socket, clipleads can be used to connect 5V and ground as required.

testing 7472s

The 7472 is representative of the J-K flip-flops, so its testing is described. Other J-K FFs may be tested similarly.

After the 7472 is plugged into the socket connect 5V and ground. Connect the CLOCK line from pin 3 of the clock generator to pin 12 of the 7472. Connect the voltmeter to the Q output, pin 8. With power on, ground PRESET momentarily (pin 13). The Q output should increase and remain at 2.4 volts (or more typically 3.5V). Ground CLEAR (pin 2) momentarily — the Q output voltage should decrease and remain at 0.22 volt typically — maximum of 0.4 volt.

Operate the switch on the clock generator. Q voltage should increase to 3.5V. Another operation of the switch and Q voltage should decrease to 0.22V. As the switch is operated, Q will alternate between high and low. With Q in the low state, ground K1, pin 9, and operate the clock switch. Q should change to high (3.5V). Remove the ground from K1 and apply it to J1, pin 3. Operate the clock switch — Q should decrease to low (0.22V). Repeat for K2 pin 10, J2 pin 4, K3 pin 11, and J3 pin 5 with the same results.

The 7470 is tested similarly; also the 7473. However, the 7473 has different terminals for 5V, ground, J, K and Q and has no PRESET or CLEAR. If clipleads are used to connect 5V and ground to the test socket, maximum cost effectiveness is achieved, particularly where only one or two ICs of a type are being checked.

The 7476 is a dual J-K FF, each with PRESET and CLEAR, and only one J and K input on each FF, in a sixteen-pin package. Testing is as for the 7472.

Fanout capability of flip-flops can be checked in the same manner as described for the NAND gates. Connect the 390-ohm resistor between 5V and $\overline{Q}$ or Q. When $\overline{Q}$ or Q is in the low state, voltage should be 0.4 volt or less.

Checking 7490s seemingly presents an added level of complexity; however, the simple tools described above can be used just as effectively. More time is required, since four FFs and several gates are involved, with four output lines to observe.

The test socket for the 7400 can be used if clipleads are used to connect 5V (pin 5) and ground (pin 10). Pin 3 of the 7400 clock generator connects to pin 14, and pin 12 connects to pin 1 for decade counting. Reset lines pins 2, 3 and pins 6, 7 are connected to ground. The BCD output lines are pins 12, 9, 8 and 11 weighted as follows: pin 12 = 1, pin 9 = 2, pin 8 = 4, and pin 11 = 8. Counting is from zero to 9.

Resets should be checked before checking the counting function. Lifting ground momentarily from pin 2, 3 should reset count to ZERO. All outputs should read less than 0.4V (typically 0.22V). If ground is left on either pin 2 *or* 3, reset cannot take place.

Lifting ground from pins 6, 7 momentarily should reset to 9. Pins 1 and 11 voltages should be more than 2.4 volts, while pins 9 and 8 voltages are less than 0.4 volt. Reset the counter to zero to prepare for counting.

Each clock pulse; that is, each operation of the clock generator switch, should advance the 7490 count by one. The first clock pulse should cause the voltage at pin 12 to increase to 3.5V typically. Pins 9, 8 and 11 should remain low. The second clock pulse should cause the voltage at pin 9 to go high, others low. The third clock pulse causes voltage at pins 12 *and* 9 to go high; others remain low. The process continues until the count reaches nine — pins 12 and 11 are high. The next clock pulse brings all outputs to low.

More elaborate arrangements can be devised easily using a monostable multivibrator as a clock generator with an oscillator to drive it. Small discrete LEDS could serve as output indicators. Each LED can be connected to 5V through the 330-ohm line resistor, then to one of the outputs. The display would be reversed; TRUE would turn the LED off.

Simple test setups as described above should serve the occasional builder for most applications. Obviously, not all IC specifications are checked by these simple tests. For instance, rise and fall times, thus speed of operation, are not checked. When the construction project is expected to operate at speeds near the limit of TTLs, these tests may fail to reveal those faults.

ham radio

equations for determining antenna parameters

Horizontal antenna relative dB power gain versus terrain tilt, height, and vertical wave angle

If you're planning a new antenna installation, there are some questions you may ask:

1. I have enough money to either raise my present antenna or buy a new, larger antenna with more gain. Which option gives the most bang for the buck?

2. I live on the side of a hill that slopes 5 degrees downward to the east and 5 degrees upward to the west. What is the optimum tower height for 14-MHz low-angle radiation toward the east? Can I save money by using a smaller tower (that is, compared with another location on level terrain) if contacts toward the east are my major concern? How many low-angle, 14-MHz dBs will I lose toward the west?

3. I'm considering the purchase of either a 40-foot (12-meter) or 55-foot (17-meter) tower. How many dBs will I gain at low DX wave angles on each Amateur band with the higher tower?

4. I live on top of a hill, but the hill starts sloping downward 800 feet (244 meters) from my location. How much gain do I actually realize from this hill site at low DX wave angles for each Amateur band with an antenna H feet (or meters) above local terrain?

I have fitted equations to the data in the ARRL *Antenna Book* (reference 1), providing quantitative answers to the questions listed above. I've also written a program in BASIC that can be adapted to most of the popular programmable handheld calculators. This program and output listings are available to interested readers.*

calculator equations

Define: h = *antenna height in wavelength units,* λ, *above perfectly conducting ground*

F = *frequency (MHz)*

H = *antenna height, feet or meters*

then $h = FH/983.5$, *H in feet*

$h = FH/299.8$, *H in meters*

Define: θ = *vertical radiation angle (deg)*

*For a copy of the BASIC program and output listings, send a self-addressed envelope with 27 cents postage and $2.50 to cover reproduction costs to Robert W. Hume, KG6B, 1627 1st Street, Manhattan Beach, California 90266.

By Robert W. Hume, KG6B, 1627 First Street, Manhattan Beach, California 90266

$(\theta = 90$ *deg vertically upward)*

α = *ground tilt (deg)*

$(\alpha = 0$ *for horizontal terrain;*
$\alpha < 0$ *transmitting downhill)*

The relative dB power gain, G_R, due to direct and reflected waves (from reference 1, page 46) is:

$$G_R = 20 \log_{10} \{\sin[360° h \sin(\theta - \alpha)]\} \quad \text{dB power for } \alpha < \theta < (180° + \alpha) \qquad (1)$$

The relative dB power gain G_{RR} due to change in antenna radiation resistance with height h is (from reference 1, page 54):

$$G_{RR} = -10 \log_{10} \frac{R_h}{R_0} \text{ dB power} \qquad (1A)$$

where R_h = *radiation resistance at height h*

R_0 = *free-space radiation resistance*

For a half-wave horizontal dipole, the following fitted equations apply (reference 1, page 50):

$$(R_h/R_0 = (2.671\, h + 6.85\, h^2) \quad \text{for } h \lesssim 0.234 \qquad (2)$$

$$R_h/R_0 = \{1 + 0.419 \exp[-(h - 0.234)/0.6] \sin[700°(h - 0.234)]\} \quad \text{for } h \gtrsim 0.234 \qquad (3)$$

$$R_0 = 73 \text{ ohms} \qquad (4)$$

The ratio (R_h/R_0) is the normalized change in radiation resistance with height and depends on the type of horizontal antenna (*that is*, G_{RR} for a dipole and a Yagi is not the same).

The total relative dB power gain, G, due to both reflection and radiation resistance effects is

$$G = (G_R + G_{RR}) \quad G(\theta, h, \alpha) \text{ dB power} \qquad (5)$$

Define a terrain tilt gain, G_α, about fixed values of θ_0 and h_0 as follows:

$$G_\alpha = G(\theta_0, h_0, \alpha) - G(\theta_0, h_0, \alpha = 0) \qquad (6)$$

G_α represents the relative dB power gain at ground tilt α compared with horizontal ground when h and θ remain fixed. Note that since h_0 is fixed, the G_{RR} part of G will subtract in the difference, giving a result depending only on the G_R part of G. Thus G_α is valid for any type of horizontal antenna.

The explicit solution for G_α is

$$G_\alpha = 20 \log_{10} \frac{\sin[360° h \sin(\theta - \alpha)]}{\sin(360° h \sin\theta)} \text{ dB power} \qquad (7)$$

Table 1 (reference 1, page 18) gives representative wave angles, θ, for a 3500-mile (5600-km) path between New Jersey and England.

table 1. 3500 mile (5600 km) path wave angle, θ.

F (MHz)	θ_L (1 percent low)	θ_M (median)	θ_H (1 percent high)
7	10 degrees	22 degrees	35 degrees
14	6 degrees	11 degrees	17 degrees
21	4 degrees	7 degrees	12 degrees
28	3 degrees	5 degrees	9 degrees

The 1-percent low-wave angles, θ_L, are probably representative of marginal band opening and closing DX propagation conditions. Contest operation over a fixed 24-hour period could be enhanced by *radiation at low angles* during such periods.

terrain tilt

An important question relative to attaining ground tilt gain, G_α, is how close in and far out from the antenna must the terrain tilt by α degrees? In certain cases, where the terrain starts sloping too far from the antenna, (for instance, on the broad flat top of a mountain) it can turn out that the terrain is effectively flat. In other cases, a small slope only a few hundred feet in front of the antenna can have significant G_α gain effect.

The ground-reflection gain, G_R, has maxima at angles θ_m given by

$$\theta_m = \alpha + \sin^{-1} \frac{(2m-1)}{4h} \quad \text{where } m = 1,2,3,\ldots \quad \text{and } m \lesssim \left(\frac{4h+1}{2}\right) \qquad (8)$$

The first vertical maxima $(m = 1)$ is at

$$\theta_1 = \alpha + \sin^{-1}\left(\frac{1}{4h}\right) \quad \text{for } h > 0.25 \qquad (9)$$

The distances from the antenna to the near point, X_N, and far point, X_F, of the bounce zone required to support radiation at the first maxima θ_1 are given in reference 2 as

$$\begin{aligned} X_N &= 7.12 \times 10^{-4} FH^2 \text{ feet} \\ &= 2.33 \times 10^{-3} FH^2 \text{ meters} \\ X_F &= 2.37 \times 10^{-2} FH^2 \text{ feet} \\ &= 7.77 \times 10^{-2} FH^2 \text{ meters} \end{aligned} \qquad (10)$$

As an example, a 14-MHz antenna at a height $H = 50$ *feet (15 meters)* has a first maximum bounce zone extending from $X_N = 25$ *feet (7.6 meters)* to $X_F = 830$ *feet (253 meters)* in front of the antenna. It is over this region that the ground slope is significant and over which it should be assessed to evaluate low angle G_α gain.

Figs. 1 and **2** show plots that demonstrate the significance of the equation results for low-angle radiation of interest to a DXer.

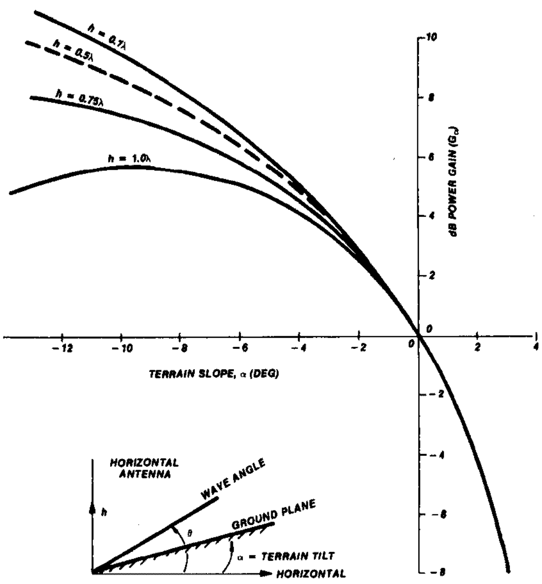

fig. 1. Horizontal antenna gain as a function of terrain slope (θ = 5 degrees).

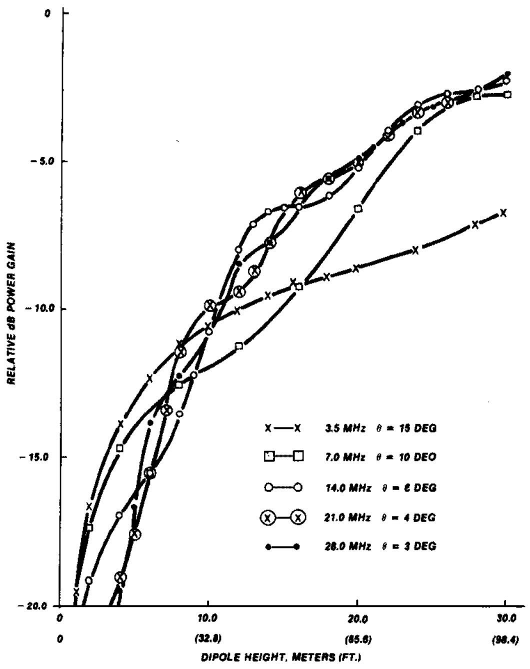

fig. 2. Dipole relative dB power gain as a function of height (level terrain; low wave angle).

references

1. *The ARRL Antenna Book*, 13th edition, American Radio Relay League, Newington, Connecticut.
2. *Reference Data for Radio Engineers*, ITT, 6th edition, page 31-12.

ham radio

making waves

a close look at an unanticipated feature

Few will deny that electronics is becoming increasingly linked to digital techniques, apparently leaving the analog world behind. Careful consideration however will show that analog techniques have not been left in the past, and this is best illustrated by examining "digital" waveforms.

Pulses, ramps, sawtooths, and square waves are all collections of many sine wave harmonics and may be described by the Fourier theorem. Logic designers should be aware of this, since this "analog composite" can affect the final circuit and waveshape.

the Fourier theorem in brief

Any repetitive waveform is composed of sine waves, harmonically related with specific relative magnitude and phase relationships. A sine wave has only one harmonic, the fundamental. Symmetrical square waves have the fundamental and only odd harmonics. A sawtooth has both odd and even harmonics.

Fig. 1 shows the formation of a square wave. **Fig. 1A** has the fundamental and a smaller magnitude, in-phase third harmonic. It appears little more than a distorted sine wave. Adding the fifth harmonic as in **fig. 1B** will start to square the result.

At the addition of odd harmonics up to the fifteenth (**fig. 1C**), the summation looks quite square. Summing *all* odd harmonics would give a perfect sine wave. Interested readers can consult texts for the mathematical details of summation.

Fig. 1D is the result of adding *many* odd harmonics. Note the slight overshoot on the edges of **fig. 1C** and the definite "rabbit ears," or corner spikes, in **fig. 1D**. These rabbit ears are a result of a *finite* number of harmonics, a "mathematically practical" square wave.

the Gibbs phenomenon

Fourier dealt with numbers to infinity. Since practical bandwidth isn't infinite, a physicist by the name of Gibbs investigated the result of distortion caused by a limited number of harmonics. This is the Gibbs phenomenon, and it applies principally to waveforms with sharp corners.

As one adds odd harmonics, the rabbit-ear spikes of the square wave become narrower until they are infinitesimally thin. Limiting the harmonics yields

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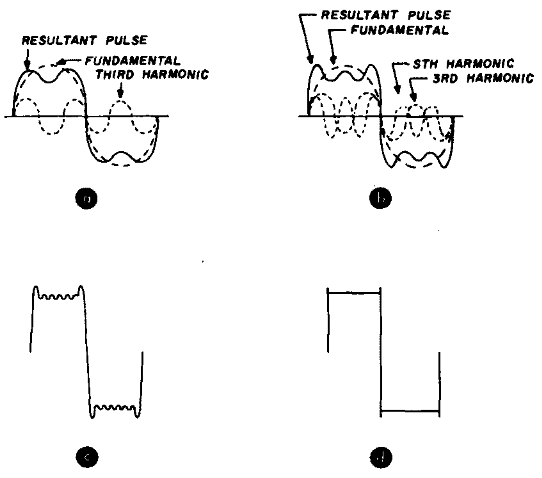


fig. 1. Evolution of a square wave from harmonics. (*A*) is fundamental and 3rd harmonic; (*B*) is fundamental, 3rd, 5th harmonics; (*C*) fundamental with odd harmonics up to 15th; (*D*) several hundred odd harmonics showing the Gibbs phenomenon corner spikes.

definite spikes. These spikes are not caused by circuit parasitics or inductive *kickback;* they are *simply* the sum of a finite number of harmonics.

now you see it, now you don't

The Gibbs phenomenon can be readily observed on low-frequency waveforms, say those at power-line frequencies. Oscilloscope bandwidth limitations, stray series-circuit inductance, and shunt capacitance all attenuate the spikes of faster waveforms.

Gibbs phenomenon rabbit ears depend on all harmonics starting with the same phase and magnitude described by Fourier. Since bandwidth reduction of measuring instruments involves both magnitude and phase shift of higher frequencies, the "mathematically perfect" square wave edges have little overshoot. The phenomenon still exists but is difficult to see at higher frequencies.

sawtooth generation

The Gibbs phenomenon can be quite prominent in a sawtooth waveshape. The sawtooth is the sum of many odd and even harmonics, and a representative waveform with ten harmonics is shown in **fig. 2**. The limitation of harmonics shows a pronounced Gibbs phenomenon overshoot.

It is well to emphasize that the summation in the square or sawtooth wave takes place in a *linear* circuit. No heterodyning is involved in these examples. One can sum lower-frequency harmonics in an op amp to synthesize any desired waveform. One such circuit is shown in **fig. 3**.

experimenting with harmonic combinations

The summing amplifier of **fig. 3** can be fed from a harmonic generator such as the one in **fig. 4**. Good results are possible by choosing a fundamental frequency in the 30 kHz range; input in **fig. 4** may be either a sine or square wave.

The resonant circuits in **fig. 4** should have a high ratio of capacitance to inductance for greatest purity at each harmonic output. Amplitude and phase adjustments are relatively independent. Stable phase-synchronous harmonics are generated — a task difficult to do with four separate oscillators.

The setup is simple for the sawtooth waveform. Phase adjustments are set so that all zero crossings occur at the same time and in the same direction relative to the fundamental. A dual-trace oscilloscope is best for this adjustment. Amplitude of the second harmonic is set for half that of the fundamental, the third harmonic is one-third amplitude, and the fourth harmonic amplitude is one-fourth the fundamental.

Combining these four sine waves in the summing

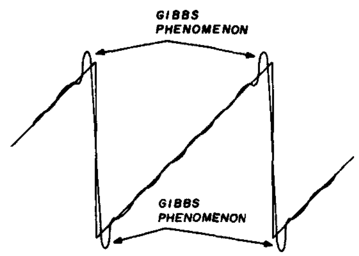


fig. 2. Sawtooth formed from fundamental and ten successive harmonics. Overshoot addition to sawtooth shape is due to Gibbs phenomenon.

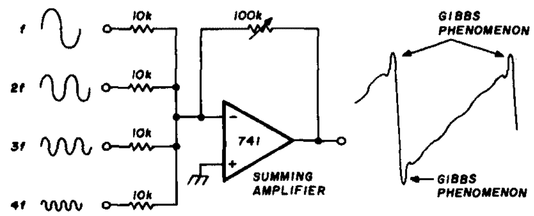


fig. 3. A summing amplifier capable of providing a rudimentary sawtooth wave from four harmonic sources.

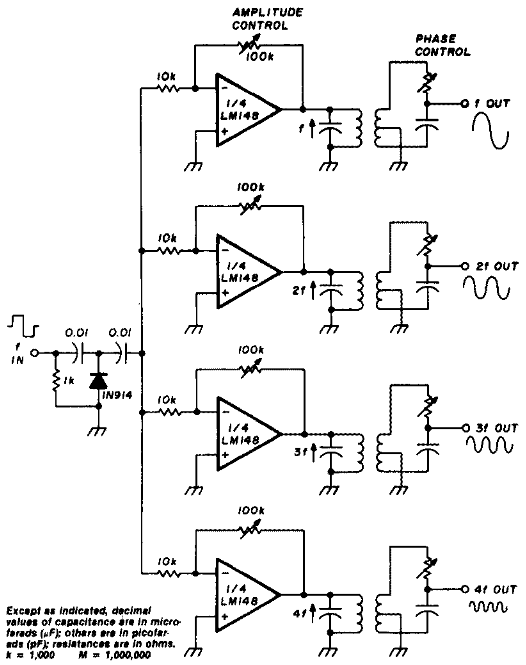


fig. 4. A four-frequency harmonic generator for synthesizing waveforms with the summing circuit of *fig. 3*.

circuit of **fig. 3** will produce a sawtooth with a clearly visible Gibbs phenomenon. Variation of amplitudes and phases can produce interesting waveforms with easily measured harmonic characteristics.

conclusion

The waveshapes discussed here are generally produced by specific digital circuitry. They can also be produced by linear circuitry using the predictable Fourier coefficients for each harmonic magnitude and phase. Awareness of the Gibbs phenomenon is bound to pay dividends. One thereby gains deeper insight regarding the simulation of musical tones. Or, perhaps, the erratic triggering of a logic circuit may be understood. And maybe it isn't semiconductor charge-storage, saturation, or inductive counter-EMF that is ruining your ideal waveform!

biblography

Bloomfield, Peter, *Fourier Analysis Of Time Series: An Introduction*, John Wiley & Sons, 1976.

Ontes, Robert K. and Loren Enochson, *Digital Time Series Analysis*, John Wiley & Sons, 1972.

Reference Data For Radio Engineers, Sixth Edition, Chapter 44, pages 44-1 to 44-14, Howard W. Sams & Co., Inc., 1975.

ham radio

HAM CALENDAR

March

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

W1AW Schedule

October 25, 1981-April 24, 1982 — MTWThFSSn = Days of Week — Dy = Daily

W1AW code practice and bulletin transmissions are sent on the following schedule:

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
	1 WEST COAST BULLETIN — 9PM PDT (8PM PST - 0400 UTC) 3540 KCS, A-1, 22 WPM — 1.	**2** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**3**	**4** WEST COAST QUALIFYING RUN — 4.	**5**	**6** ORANGE COUNTY HAMFEST — Orange County Fairgrounds, Costa Mesa. Contact Cataline Amateur Repeater Assoc., P.O. Box 2197, Westminster, CA 92683 — 6-7. INTERNATIONAL DX CONTEST — Phone — 6-7.
7	**8**	**9** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**10**	**11** W1AW QUALIFYING RUN — 11. HARTFORD COUNTY ARA AUCTION — Annual auction of used equipment and "stuff" at the Veterans Memorial, Sunset Ridge Dr., E. Hartford — 11.	**12** JEFFERSON BARRACKS ARC ANNUAL AUCTION & HAMFEST — Carondelet Sunday Morning Athletic Club, South St. Louis. Contact K0ZFK — 12.	**13** THE 22ND ANNUAL LAFAYETTE AMATEUR RADIO HAMFEST — Evangeline Downs Racetrack Club House, off Hwy. 167, 5 miles north of Lafayette. For more information contact AARA, P.O. Box 51174, Lafayette, LA 70505 — 13-14.
14 RANDOLPH ARA 3RD ANNUAL HAMFEST — Contact R.A.R.A., P.O. Box 203, Winchester, IN 47394 or W9VJX — 14. STERLING-ROCK FALLS AMATEUR RADIO SOCIETY 22ND ANNUAL HAMFEST — Sterling H.S. Field House, Sterling, IL. Contact Rodney Cushman, 107 Main St., Galt, IL 61037 — 14.	**15** WEST COAST BULLETIN — 9PM PDT (8PM PST - 0400 UTC) 3540 KCX, A-1, 22 WPM — 15.	**16** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**17**	**18**	**19** THE 3900 CLUB AND SOO-LAND REPEATER ASSOC. 6TH ANNUAL HAMBOREE — Marina Inn, South Sioux City. Contact W0FZO or K0TFT — 19-20.	**20** SOUTHERN MICHIGAN ARS & CALHOUN COUNTY REPEATER ASSOCIATION'S 21ST ANNUAL MICHIGAN CROSSROADS HAMFEST — Contact SMARS, P.O. Box 934, Battle Creek, MI — 20. PLAYGROUND ARC 12TH ANNUAL SWAPFEST — Okaloosa County Fairgrounds, Fort Walton Beach. Contact Joe Giangrosso, 304 Chickasaw Circle, Fort Walton Beach, FL 32548 — 20. CIVIL AIR PATROL'S 2ND ANNUAL SPRING HAMFEST — Lake County Fairgrounds, Grayslake. For more information send SASE to Capt. Rehm, 637 Emerald St., Mundelein, IL 60060 — 20. CHESTNUT RIDGE RADIO CLUB'S HAM RADIO FLEA MARKET — Education Bldg., Saddle River Reformed Church, E. Saddle River Rd. & Weiss Rd., Upper Saddle River. Contact W2EHD — 20.
21 WISCONSIN QSO PARTY — 1800Z, March 21 to 0200Z, March 22 (8 hrs.) — 21.* TOLEDO MOBILE RADIO ASSOCIATION'S 27TH ANNUAL AUCTION & HAMFEST — Lucas County Rec. Center, Key St., Maumee. Contact KB8YD — 21. YL ISSB QSO PARTY — 001 GMT, March 20 to 2359 GMT, March 21 (CW) — 20.*	**22**	**23** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**24**	**25** W1AW QUALIFYING RUN — 25.	**26**	**27** NEBRASKA STATE CONVENTION — Kearney — 27-28. A.R.C.H. 82 — Sponsored by the Gateway ARA. Contact Gateway ARA, P.O. Box 8432, St. Louis, MO 63132 — 27-28. RAMAPO MOUNTAIN AMATEUR RADIO CLUB'S UHF/VHF QSO PARTY — 1600 hrs. (local), Saturday, March 27 to 2400 hrs. (local) Sunday, March 28 — 27.*
28 BALTIMORE ARC GREATER BALTIMORE HAMBOREE & COMPUTERFEST — Maryland State Fairgrounds Exhibition Complex, Timonium, MD. Contact G.B.H. & C., P.O. Box 95, Timonium, MD 21093 — 28. DELAWARE VALLEY RADIO ASSOCIATION'S ANNUAL FLEA MARKET — New Jersey National Gaurd 112th Field Artillery Armory, Eggersts Crossing Rd., Lawrence Township. Contact D.V.R.A., P.O. Box 7024, W. Trenton, NJ 08628 — 28. 4TH ANNUAL LAKE COUNTY HAMFEST — Madison High School, Madison OH. Contact Lake County Hamfest, 5704 Middle Ridge, Madison, OH 44058 — 28. CONEMAUGH VALLEY ARC 5TH ANNUAL HAMFEST — Sandy Bottom Sportsman's Club, Seward, PA. Contact Conemaugh Valley ARC, 2829 Bedford St., Johnstown, PA 15904 — 28.	**29**	**30** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**31**			*See Coming Events*

*See Coming Events

operation upgrade: part 5

The fifth part in a continuing series designed to help you upgrade your ticket

This series of articles is being presented to help you pass *a higher* grade Amateur license exam, to give you the basic radio theory needed to pass a Novice, *Technician/General, or* Advanced class license test. After these basics are presented in as simple a form as possible, there will be articles covering Extra class license subjects.

This month we will examine the use of some active devices in oscillator circuits to generate either radio frequency (rf = 10 kHz to over 300 GHz) ac, or audio frequency (af = 20 to 20,000 Hz) ac.

a basic oscillator

There are a variety of methods of generating alternating current. The electromagnetic machine used to develop power-frequency ac is called an alternator. It must be rotated by some type of motor. The motor rotation may be developed by water wheels, windmills, electric motors, or gasoline engines. The rotation of a magnetic pole past coils of wire induces ac voltages into the coils.

Although in the early days of radio such electromechanical alternators were used to generate radio frequency ac for code transmissions up to 25 or more kHz by using many field poles, alternators today are usually limited to supplying power in the 30 to 800 Hz range. The lower the frequency of the ac generated by an alternator the more iron required in the machine and in the equipment with which it is used. Aircraft ac systems use 400 to 800 Hz ac to decrease the weight of their alternators and other components.

The *oscillators* used to generate af or rf ac in Amateur Radio equipment use either coils and capacitors, or resistors and capacitors, to determine the frequency at which the circuits can oscillate. Active devices are used to produce an amplified ac energy that is fed back to keep the circuits producing ac. There are a

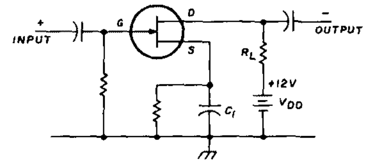


fig. 1. A basic JFET amplifier produces a 180° phase reversal of any input signal voltages.

By Robert L. Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

great many types of oscillator circuits, but they usually require an in-phase (0° or 360°) feedback circuit involving either one or two active device stages. We will discuss some single device oscillator circuits first.

Before starting on oscillator circuits, let's look at the phase reversal that occurs in a standard amplifier, such as the *grounded source* amplifier shown in **fig. 1**. It is called a grounded source circuit because the source is held at ac ground potential by the bypass capacitor C_1. The input signal is fed to the gate, and the amplified output signal appears at the drain of the JFET. Suppose a positive-going signal is fed to the gate (indicated by the + in the diagram). Such a positive voltage will produce an increased drain current (I_D) through R_L. With an increase of I_D through R_L the voltage-drop across this resistor will increase. When the gate is driven positive the increased I_D through R_L produces an increased voltage-drop across R_L, resulting in the drain voltage becoming less positive. This is the same as saying the drain terminal becomes more negative. So, whatever polarity signal is fed to the gate will show up as an amplified signal of opposite polarity (180° out of phase) at the drain. Thus, the basic amplifier shifts the phase of any signal fed to it by 180°.

Armstrong oscillators

One of the oscillator circuits that can be used in a one-active-device (FET, BJT, VT) circuit is the Armstrong oscillator, **fig. 2**. In this circuit, if ac is developed in the L_1C_1 circuit for any reason, some of this ac voltage is fed through C_2 to the gate; it's amplified, and shows up across the drain circuit load, in this case the "tickler" coil. Capacitor C_{bp} bypasses one end of the tickler to ground, completing the ac drain circuit through the tickler to the source. The dc drain circuit is from D, through the tickler, RFC, V_{DD}, to S. Can you see that if the tickler coil is placed close to L_1, any expanding and contracting magnetic fields from it would induce an amplified ac into L_1? If the tickler turns are reversed, any ac voltage induced into L_1 would then be reversed 180° in phase. If the tickler is wound one way, ac induced into L_1 by varying currents in the tickler would be in phase (*regenerative*) and would add to any ac present in the LC circuit. The whole *stage* is then working to keep electrons in the L_1C_1 circuit oscillating. If the tickler turns are reversed, the ac EMF induced into L_1 would now be out of phase (*degenerative*) and would prevent the LC circuit from oscillating. To start the LC circuit oscillating at its normal resonant frequency, assuming regenerative feedback, it is necessary only to close the switch in the drain circuit. This produces a dc surge through the tickler coil. The result is a sud-

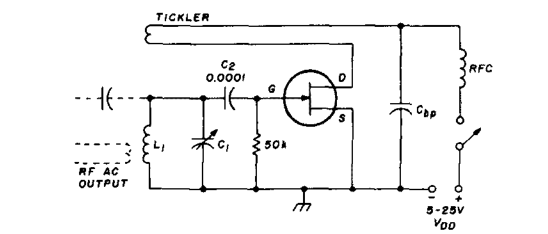


fig. 2. Armstrong oscillator circuit to generate rf ac.

denly expanding magnetic field from the tickler that induces energy into the LC circuit and starts electrons oscillating back and forth in it. (The tickler coil usually has about one-fourth as many turns as are used in the LC circuit coil.)

Back in the twenties, the Armstrong circuit using a triode vacuum tube was a very popular high-sensitivity oscillating detector and is still used as a 160, 80, and 40 meter detector-receiver by experimenting Amateurs. When used as a receiver, C_{bp} is made variable to control feedback and the point of oscillation. Earphones are connected in series with the switch.

tuned-input-tuned-output oscillators

The Armstrong circuit is an inductive feedback oscillator. The tuned-input-tuned-output circuit shown in **fig. 3** is a capacitive feedback oscillator. Both of its LC circuits are tuned to the same frequency, 3.7 MHz for example. When the switch is closed, L_2C_2 has an "exciting" shock of current developed in it, which drives this circuit into flywheel-type ac oscillations at 3.7 MHz. This ac frequency is fed to the L_1C_1 circuit by any natural drain-to-gate capacitance that might exist, or by distributed capacitance of circuit wires being near each other, or, if necessary, by adding a 5-pF feedback capacitor, C_{fb}, shown dashed.

In the early days of Amateur Radio this "self-excited" oscillator circuit, using a triode VT, was known as a TPTG (tuned-plate-tuned-grid) oscillator, and was used as a simple CW transmitter. Today it is almost never used as an oscillator unless a *quartz crystal* (xtal) is substituted for the L_1C_1 circuit. However, you may run up against this kind of oscillator in receiver or transmitter amplifier stages that have tuned input and tuned output circuits in them. If care is not taken to prevent capacitive feedback coupling in such amplifiers they may begin to oscillate instead of amplify! This is very undesirable. *Neutralization*, a form of degeneration discussed in later articles, must be used to prevent such oscillations.

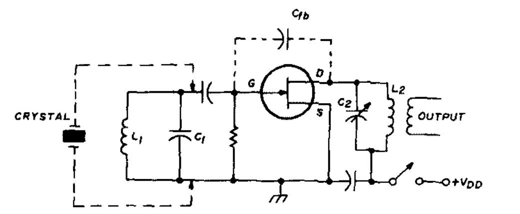


fig. 3. Tuned-input-tuned-output self-excited oscillator, or crystal oscillator if a crystal is being used as the input tuned circuit.

If a wafer of quartz crystal is sliced out of raw quartz, is ground perfectly flat, and is silver-plated on its two flat surfaces, it will have some very interesting characteristics. If the two plates are pressed together a voltage will be developed between the two plates. As the plates are released an opposite potential voltage *will* be developed between them. Conversely, if a dc voltage is applied across the plates the crystal wafer will contract. If the opposite polarity voltage is applied the wafer will expand.

These two reciprocal mechanical-electrical effects operate in much the same way as the electrostatic-electromagnetic effects of an oscillating LC circuit. The crystal must be ground precisely to the proper physical dimensions to vibrate and oscillate at the desired frequency, just as the inductance and capacitance values of an LC circuit must be chosen to produce oscillations at the desired frequency. In this circuit the crystal acts as a very high-Q LC circuit. Thus, by substituting the crystal (dashed) for the "self-exciting" L_1C_1 circuit in **fig. 3**, you would develop a very stable (unchanging frequency) oscillator. Although a few picofarads of capacitance across a crystal may lower its resonant frequency a few hundred hertz, crystals are considered to produce single-frequency oscillations. If you wish to change frequency when using a crystal-oscillator-type transmitter, you must switch in a crystal ground to some other frequency. Crystals are usually encapsulated in tiny plastic or metal holders, or cans, with two connector pins protruding out the bottom. The pins fit into special crystal sockets so that crystals of different frequencies may be plugged into the circuit when a change of frequency is required.

Hartley oscillators

One of many *variable frequency oscillator* (VFO) circuits is a combination inductive capacitive feedback circuit called a Hartley oscillator, **fig. 4**. Can you see that the resonant frequency in this LC circuit would be determined by C_1 across both L_1 and L_2 in series? Note that L_2 is actually a tickler coil of an Armstrong portion of this circuit. Also, that C_1, C_2 and C_3 form the drain-to-gate feedback capacitance for a capacitive-feedback-type of oscillator. Where on the coil the tap is placed determines the power output and the frequency stability of the oscillator. The fewer tickler turns the lower the power output but the better the frequency stability. The more tickler turns the higher the power output but the poorer the stability. A good compromise is to have L_1 with about twice as many turns as L_2. The radio-frequency choke coil (RFC) prevents the capacitance C_4 across the V_{DD} power supply from ac-shorting the tickler coil (L_2), which would stop oscillations.

Capacitor C_2 and resistor R_1 make up the *class C* (discussed later) grid-biasing circuit. Within limits, the higher the value of R_1 the greater the negative bias, the lower the power output, but the better the stability. R_1 may range from 10 kilohms to perhaps 2 megohms, depending on the requirements of the oscillator. C_2 is usually 50 to 100 pF. Although shown with a JFET, BJTs and VTs can be used in these circuits. The low impedance of the input circuit of a BJT may require the base connection (through C_2) be tapped down L_1 about half way.

Colpitts oscillators

The most popular of today's VFOs is the Colpitts, **fig. 5**, or one of its many variations. Whereas the Hartley uses a tap about two-thirds of the way down its LC circuit inductance, the Colpitts taps down the capacitance of the LC circuit by making C_3 about twice the value of C_2. C_1 in this diagram is a small trimmer capacitor used to tune the oscillator a relatively few kilohertz (across a single Amateur band, for example). Energy can be taken capacitively from the top of the LC circuit in any of these oscillators, or inductively by using a secondary coil coupled to L_1.

You are much more likely to see the Clapp form of

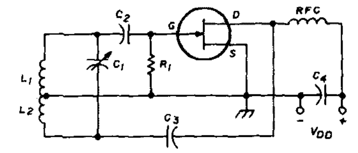


fig. 4. Hartley oscillator, shunt fed (no I_D flowing through a tuned circuit).

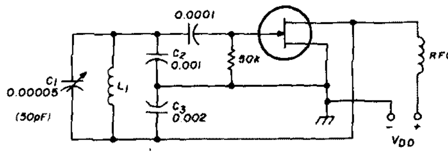


fig. 5. Colpitts shunt-fed oscillator.

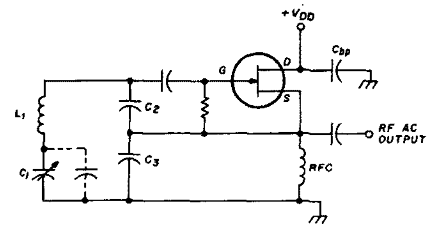


fig. 6. Clapp oscillator, a form of Colpitts.

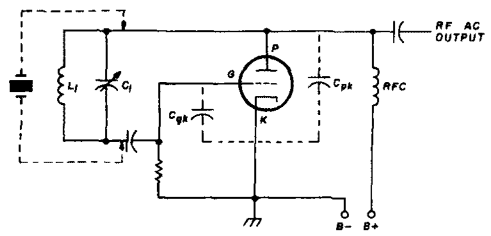


fig. 7. Ultra audion VHF and UHF oscillator becomes a Pierce high-frequency oscillator if a crystal is used as the resonant tank circuit.

the Colpitts oscillator, **fig. 6**. Such a circuit permits the tuning capacitor, now in series with L_1, to have one of its terminals grounded. This is very desirable because it makes insulated tuning shafts from panel knobs to the tuning capacitors unnecessary. Usually in this circuit only the relatively small rf ac voltage developed across C_3 (and the RFC) is used as the rf ac output. As a result, these oscillators are usually followed by a low-power rf amplifier to bring the oscillator ac up to a usable amplitude. Such a "buffer" amplifier also tends to isolate the oscillator from external circuits which might affect the oscillator's frequency. You will usually find a fixed capacitor, shown dashed, connected across C_1 to increase the strength and stabilize the output amplitude of Clapp-type oscillators.

The higher the frequency of oscillation the smaller the required capacitances (and inductances) of any oscillator circuit. For example, an oscillator used in the VHF range (30 to 300 MHz) or higher is the "ultra-audion," which was popular with vacuum tubes (and operates with FETs), **fig. 7**. Here the very small value inter-electrode plate-to-cathode and grid-to-cathode capacitances, shown dashed, act as C_2 and C_3 across the LC circuit of a Colpitts oscillator. Of more importance, a crystal, also shown dashed, can be used in place of the LC circuit, providing a simple *Pierce*-type crystal oscillator which requires no tuning coil or capacitor at all. The Pierce-type crystal oscillator is quite popular.

Note that the oscillator circuits shown are all developing rf ac. Af ac oscillator circuits would be similar but would use iron or ferrite cored inductors and relatively larger inductance and capacitance values to enable oscillations at such lower frequencies.

harmonic and overtone oscillators

If it is desired to have crystal-controlled oscillations in the 28-MHz range, the crystal for such a high frequency will be very thin and fragile. For low power circuits, such as with small transistors, crystals at this frequency may be practical. More often, lower frequency crystals are used and harmonics of their fundamental frequency of oscillation are picked off. One such circuit is shown in **fig. 8**. When the 7-MHz drain LC circuit is tuned to the frequency of the crystal (actually to a slightly higher frequency to produce the necessary feedback phasing), the crystal oscillates. The second L_2C_2 circuit might be tuned to the third harmonic of 7 MHz, or 21 MHz. However, the rf ac power output from this LC circuit will be much less than the power generated at 7 MHz. If the harmonic circuit were tuned to the fourth harmonic of 7 MHz, then 28 MHz rf ac would be the output from L_2C_2, but at a still lower power level.

The reason harmonic energy can be picked off with this circuit is that the active device is biased to such a high value (class C) that the drain current is developed as very narrow pulses widely separated from the next pulse. As a result, the pulses shock-excite the LC circuits, which may oscillate back and forth several times before the next pulse arrives. If L_2C_2 is tuned to the second, third, or fourth harmonic of the crystal frequency, the resonant circuit by its flywheel oscillations will produce very nearly sine-wave rf ac at that harmonic frequency. The harmonic output will always be an exact whole number multiple of the crystal's oscillating frequency.

While we think of crystals as having a basic fundamental vibration frequency, it is found that they may also oscillate or vibrate in an odd number of layers. That is, a 4-MHz crystal will vibrate longitudinally at 12 MHz (three times 4 MHz), or at 20 MHz (five times

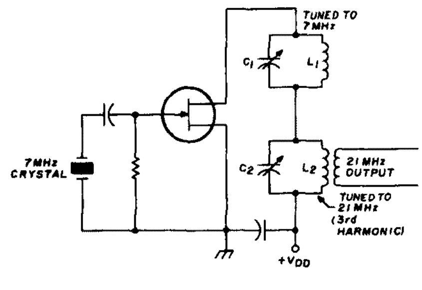


fig. 8. Harmonic output crystal oscillator.

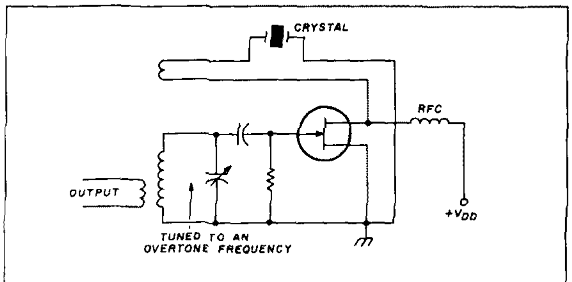


fig. 9. One form of an overtone crystal oscillator.

4 MHz), and possibly at 28 MHz (seven times 4 MHz). To make the crystal oscillate at such *overtones* the crystal might be connected in series with the tickler coil of a shunt-fed Armstrong circuit, **fig. 9**. This circuit is said to be *shunt-fed* because the crystal, a nonconductor, forces pulsating drain dc to be fed from the drain to $+V_{DD}$ through RFC instead of through the tickler. The tickler, with the crystal in series with it, can have only rf ac flowing in it. The circuit shown back in **fig. 2** is a *series-fed* oscillator, because I_D is flowing through one of its coils.

Another overtone circuit can be developed by adding a crystal in series from the FET source to the LC center-tap of the Colpitts oscillator shown in **fig. 6**. The LC circuit of the oscillator *must be tuned to the overtone*, not the fundamental frequency, of the crystal. Actually, the overtone frequency is near, but is never an exact multiple of, the crystal's fundamental oscillation frequency. If overtone crystals are required at a given frequency, the crystal manufacturer must know which overtone is to be used and the desired operating frequency, in order that the crystal can be ground to a correct fundamental frequency.

Another popular type of stabilized crystal oscillator, called a *phase-locked loop* (PLL), will be explained in a later article.

RC oscillators

There is a family of oscillators which fall into the category of *RC oscillators*, because they depend on the charging and discharging time of capacitors through resistances to determine the frequency of their oscillations. In most cases these oscillators use two cascaded (one following the other) single-ended grounded-source (-emitter, -cathode) active devices with some means of feeding back from the output of the second stage to the input of the first, as in **fig. 10**. Since both stages are grounded-source types, there is 180° phase shift through each stage, or a total of 360° (same as 0°, or in-phase) feedback by C_2 from the drain of Q_2 to the gate of Q_1. C_1 alternately charges and discharges through R_2, and C_2 alternately charges and discharges through R_1. The values of these RC pairs determine the frequency of oscillation. If C and R are both large values the time of charge and discharge is long, and the oscillation frequency is low. With small C and R pairs the oscillation frequency will be high.

The voltage-drops developed across R_1 and R_2 will be relatively slow charging and fast discharging, resulting in sawtooth-shaped ac waves available from the tops of these resistors. Q_1 and Q_2 alternately turn on and turn off as the bias values change from high values to the point where drain current just begins to flow. Since the circuit is regenerative (in-phase feedback), once drain current starts to flow the transistors switch on (to maximum I_D) almost instantaneously. As a result, voltages taken from the drain terminals will be squarewave pulses of dc caused by the rapid on-off switching of the device. If the output load is coupled through capacitors, the pulses of squarewave dc become squarewave ac cycles in the load. If R_1C_2 has a fast time constant and R_2C_1 has a slow time constant, a narrow pulse will be developed by Q_1 and a wide pulse will be produced by Q_2. Such a circuit can produce narrow pulses from Q_1 spaced relatively widely apart in time. Narrow pulses of this type can be used as triggering signals for some other circuit.

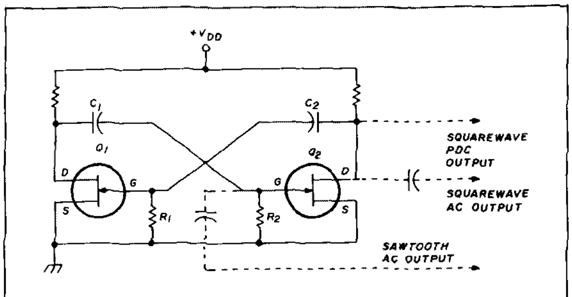


fig. 10. Multivibrator, RC, or relaxation oscillator.

FCC test topics

The following Novice test topic is discussed in this article, but should be understood by Technician/General and Advanced applicants *also*:

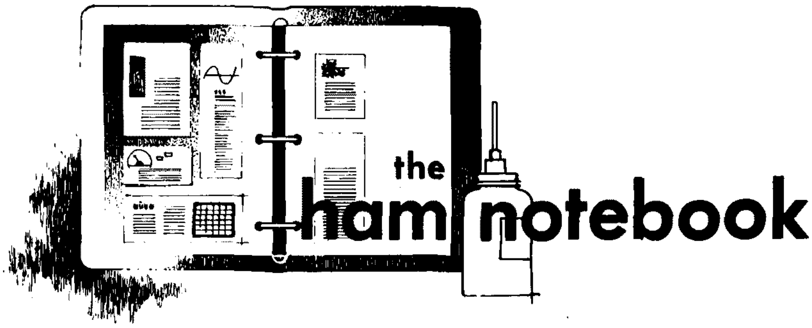
- quartz crystals, appearance, applications, symbol.

The following Advanced class test topics are discussed in this article:

- oscillators, various types, applications, stability.

For more information on these subjects it is recommended that you refer to a textbook such as *Electronic Communication*, by Robert L. Shrader, McGraw-Hill Book Company, available through Ham Radio's Bookstore, and to radio handbooks.

ham radio



external microphone for the TR-2400

My new TR-2400 finally arrived, complete with earphone, charger, and battery pack. After I spent an hour playing with the buttons and learning how to use the controls, it was on the air, and the reports started coming in: "Super audio quality," "Sounds great," and "Terrific speech quality!" The 2-meter synthesized handheld made by Kenwood certainly met all my expectations.

After a few weeks of use at home, on a trip, and in the car, I realized that an external microphone would be a valuable addition. Why pick up the whole set, when only the microphone has to be used? A quick review of the instruction manual revealed that Kenwood recommended using a 2-kilohm capacitor microphone, or else a dynamic microphone with a series 0.47-1.0 μF capacitor to block dc voltage. In addition, the microphone cable must be equipped with an external 1/8-inch miniature and a 3/32-inch microminiature plug (furnished as accessories with the radio) to mate with the external microphone and standby jacks.

Looking through my collection of microphones, I found a capacitor microphone element (removed from an old cassette recorder) and two dynamic microphones, one of which had the correct mating plugs used in the same cassette player. One by one each microphone was tested, and each time the audio reports came back: "Sounds awful," or "Sounds like you're in a barrel," or "Sounds pretty good, but not as good as the internal microphone." A variety of capacitors and microphone holders were tried, but to no avail.

The next day I called Kenwood to find out if a small capacitor microphone with mating plugs was available, and was told that there was none at this time. I inquired about the internal microphone and found out it was a small Electret microphone, available as a replacement part for $5.00 plus $2.25 for shipping and handling. It was stocked as part no. T91-0312-05, "Condenser Microphone." I ordered one from stock, and received it by mail in a few days.

I discovered it really *was* small, about 1/4 inch (6.4 mm) in diameter! The microphone contains an internal FET amplifier and is designed to operate into a circuit that provides around 7 volts dc through a load resistance. The circuit used by Kenwood from the external microphone jack is shown in **fig. 1**; the connections to the polarized microphone terminals are shown in the insert.

I decided to mount the microphone and a microphone holder.

Carefully unsolder the microphone element. A 3/4 inch (19 mm) rubber grommet with a 1/4-inch (6.4 mm) hole mates snugly with the microphone holder, and also with the capacitor microphone element. As the grommet was too thick, I first cut down the grooved section with a razor, splitting it into two 3/4-inch (19-mm) round washers; one of the resulting washers was used. The microphone element was pressed into the hole. It makes a snug fit, so cement wasn't necessary.

Next, solder the wires carefully to the microphone element, observing polarity. The wire going to the tip of the plug is the positive connection and should be soldered to the *smaller* of the two microphone terminals (if your microphone doesn't work, try reversing these connections). The rubber grommet can now be pushed into the microphone holder so that it is flush with the end. A piece of 1/4-inch (6.4 mm) thick foam plastic (the yellow, fluffy variety) can be cut to fit over the element to reduce the effect of wind on the microphone, if it is to be used for mobile work. The foam fits snugly between the element and the screw cap cover.

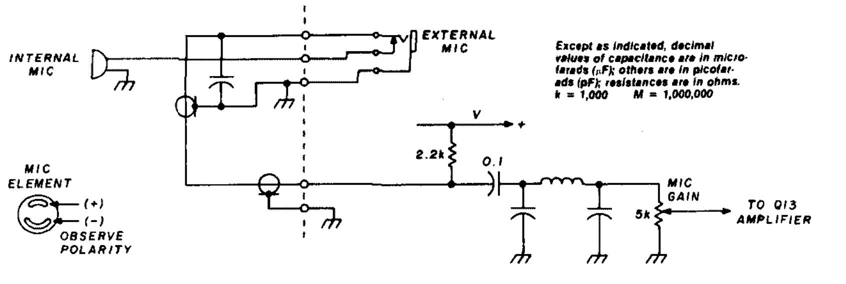


fig. 1. Circuit used by Kenwood from the external microphone jack. Connections to the polarized microphone terminals are shown in the insert.

element into my cassette microphone holder with the mating cables. An identical microphone is made by Radio Shack, part no. 33-1054 (1980 catalog, $4.99), "Low Cost Dynamic Microphone." This microphone comes with a slide switch on the case

My first tests with the microphone were, as they say, good news and bad news. The good news was that the audio was excellent — the same high quality as the internal microphone (after all, it is the *same* microphone). The bad news was that

microphone gain was too high, a particular problem on one local repeater that provides speech clipping to discourage excess gain.

A check of the transceiver circuit revealed that both the internal and external microphones were controlled by the same gain control. Any adjustment of the control for the external microphone would change the gain for the internal microphone as well. A gain control was needed for the external microphone.

The circuit of **fig.** 2 was constructed on a breadboard and found to work perfectly to reduce gain. The

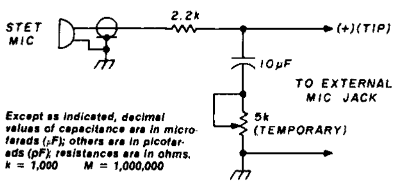


fig. 2. Attenuator circuit for reducing microphone gain.

best results were with a 2k setting of the pot, which was replaced with a 2.2k resistor. I found 1/4-watt resistors to be nice and compact. A non-polarized 10-μF tubular electrolytic was used as the capacitor. The network was soldered together as a compact array by clipping the leads short. Connect the leads to the microphone element, and tape the bare wires with plastic tape. Another small piece of plastic foam holds the components snugly inside the microphone case without rattling.

The final results were gratifying. No one has been able to tell the difference between the internal and the external microphones — the final test of perfection! A further discussion with Kenwood indicated that the microphone elements are probably quite variable from unit to unit, so the final values of the resistance network (if needed) will have to be determined experimentally; but the results make it all worthwhile.

Herb Bresnick, WB2IFV

TI58/TI59 calculator programs

Programs are now available from *ham radio* for the following items:

antenna bearing and distance between stations

This program gives the necessary antenna pointing information and the distance between locations for any latitude/longitude coordinates on the earth. It should be of great help to DXers, and those interested in meteor scatter work.

EME elevation/azimuth

This program gives small calculators the abilities of a computer. Using information found in the current year's nautical almanac, the program prints out the elevation/azimuth information in 15-minute increments. Only a few keystrokes of input are needed to run an entire day's output of moon coordinates. This program eliminates tedious manual calculations and paperwork and should prove invaluable to moonbounce operators.

(These programs will be provided free of charge for six months by *ham radio* upon receipt of an 8½ by 11 inch envelope and $1.03 in postage. After six months, there will be a reprint charge of $2.50 — Ed.)

Brian M. Manns, K3VGX

taming set screws

The knob on the function switch of my transmitter kept getting loose on its shaft. The set screw was a slotted-head 6-32 (M 3/5) machine screw. I replaced the set screws with Allen-head units, which cured the problem.

I've worked around machinery all my life and have never had much luck with anything but Allen-head set screws.*

Orville Gulseth, W5PGG

*The same problem on a Drake R-4C receiver was cured by using Allen-head set screws. **Editor.**

electronic timer

Here is a handy little gadget for the ham shack. I'm long winded, so it prevents me from over-talking the local 2-meter repeaters. The time range is 1-15 minutes. It also works well as a 10-minute ID reminder for the low bands.

The LM-741 op amp is the heart of the timer. It is connected as an inverting differential comparator. The reference voltage is taken from the junction of two 10k resistors. The resultant 6.75 V is connected to the inverting input (pin 3) of the LM-741 (see **fig.** 3). The 23 mA below V_{CC} 13.8 V is the measured current through the buzzer, transistor, and LED. Thus the LED operates in its safe region with full brightness.

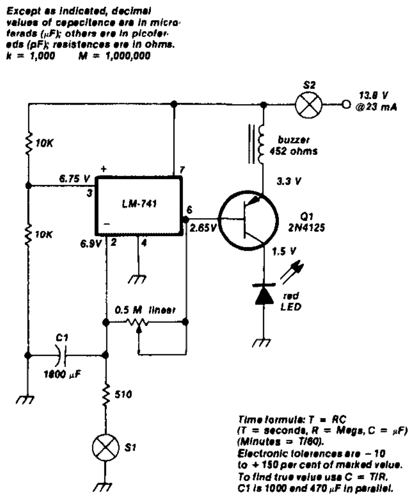


fig. 3. One to 15-minute timer. Voltages shown are with Q1 conducting. Mini-buzzer (6 - 9 V) is $1.95 at Jameco Electronics, Belmont, California 94002.

The control voltage is picked up from output pin 6 of the LM-741, passes through the 0.5-meg linear time-setting pot to pin 2. The capacitor is discharged through the 510-ohm resistor, which prevents damage to the LM-741 and the capacitor that would be caused by a dead short. Discharge time is roughly one sec-

ond. S1 is a dpdt switch to activate and reset the timer.

To operate, switch S1 to **ON**. Pin 6 voltage should be just below the supply voltage and positive with respect to Q1 emitter. The transistor is reverse biased and can't conduct. Voltages are: pin 2, 0 volts, pin 3, 6.75 volts, and the transistor base the same as at pin 6. The emitter is negative with respect to base. Collector voltage is zero.

When C1 charge reaches one-half the supply voltage, the LM-741 operates and the voltage at pin 6 drops. Switching-transistor Q1 conducts, and the following voltages will be present: emitter 3.3 volts, base 2.65 volts, and collector 1.5 volts. The LED and buzzer are then activated. They are pulsed to better catch the user's attention. The transistor bias is 0.65 volt, and current is 23 mA.

Denver V. Tolle, W9EBT

S-line QSK noise

When I initially modified my Collins S-line for CW QSK, I used a circuit described by Shafer.[1] I found, however, there still existed a certain amount of hash being generated by the exciter, which was picked up by the receiver even when the final amplifiers were cut off. Although far below the level produced by the final amplifiers, it was still sufficient to be annoying and hamper weak-signal reception. The culprit was the rf amplifier, V6. Since ALC voltage is fed to the control grid of this tube during SSB operation, I felt that, rather than grid-block key this stage, a simpler method would be to apply the same treatment as the final stage had received; namely, removal of screen voltage during standby.

R-38, either 4700 ohms or 100k depending upon production model, was removed and replaced with a 56k, 1/2-watt resistor. The B-plus end was not returned to its original location; rather, it was wired to **J9**, one of the PA DISABLE jacks. This jack (to which the final-amplifier screens are also attached) has no voltage on it during key-up conditions when using the QSK circuit mentioned above. Thus, both the final amplifiers and the rf amplifier are cut off during receive, and absolutely no hash is audible in the receiver during operation. Keying is unaffected. See fig. 4 for details.

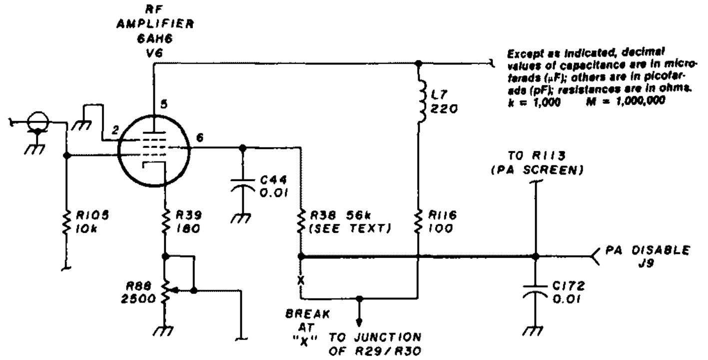


fig. 4. Rewiring R-38 in the 32S-3 eliminates hash during CW QSK operation.

reference

1. David P. Shafer, W4AX, "Cleaner Break-In With The 32S-3," *QST*, November, 1964, pages 46-47.

Paul K. Pagel, N1FB

low-frequency crystal oscillator

For years I've been collecting transistor crystal-oscillator circuits hoping to find one that would work using a 455-kHz crystal, but none would oscillate. I stumbled onto this circuit while building a BFO and am quite happy with it.

The circuit needs a little explanation. Most all crystal-oscillator circuits show a bypass capacitor between emitter and ground. I could not make this circuit oscillate when

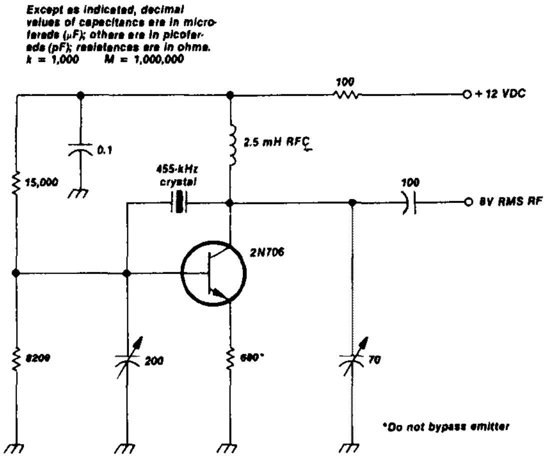


fig. 5. 455-kHz crystal oscillator.

sidetone for the Atlas 210 transceiver

One disadvantage of the Atlas 210 when operating on CW is that it has no sidetone provision. When faced with this problem, one of my Amateur friends tossed his Atlas on my bench for a solution. The following circuit is the result of the work, and has proved very satisfactory.

In **fig. 6**, Q1 and Q2 act as a simple audio oscillator and the frequency is adjusted by altering C1 to suit the operator. Q3 acts as a keying transistor simultaneously with transmitter keying.

This oscillator operates from about 6 volts, and so a simple regulator is used to keep its voltage relatively constant. The rest of the circuit is that recommended by the manufacturer for break-in CW operation. This unit was built in a small box; the keying output goes to the key jack on the Atlas, and the key plugs into the jack on the minibox.

B.E.G. Goodger, ZL2RP

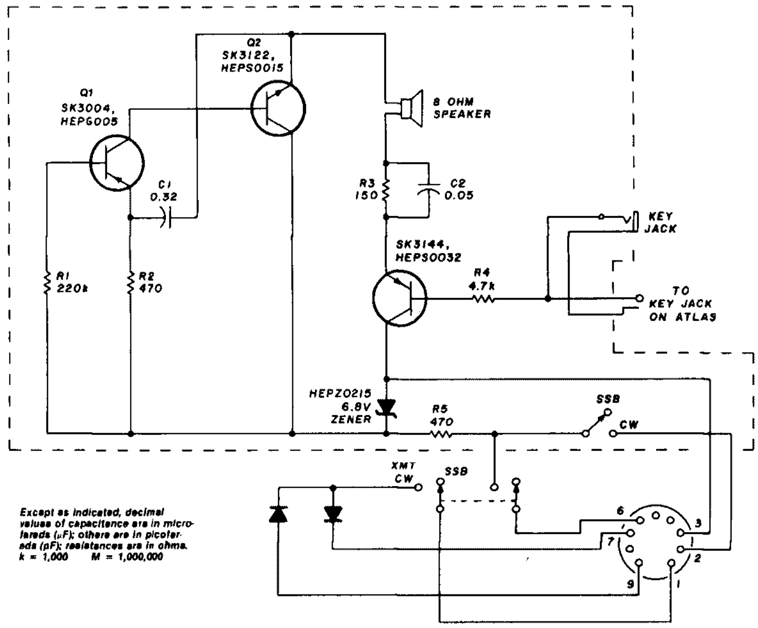


fig. 6. Modified Atlas circuit for CW sidetone with addition of connection of wire from white lead inside to pin 9.

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the emitter was bypassed. Mine would not work until I put in a 2.5 mH rf choke. The next discovery I found, when using two variable capacitors, was that the capacitance from base to ground had to be larger than that shown in my collection of oscillator circuits. Also I found it necessary to increase the value of the capacitor from base to ground. Juggling the two variable capacitors (**fig. 5**) gave the most oscillator output. The oscillator puts out 8 volts rms of rf.

I used a 2N706 transistor, but others of the NPN type such as the 2N2222 should work. The crystal was a metal-can-type HC-6.* The FT-241 was not tried as I didn't have any on hand. I tried using FET MPF-102s at 455 kHz but could make none of the circuits work, although the handbooks show many low-frequency oscillators using them.

A capacitor was inserted in series with the crystal, my hope being it would vary the frequency a bit. It is also supposed to have a negative reactance to the crystal, which would be shifted into the positive-reactance region. I found the series capacitor did nothing. The oscillator worked just as well with the crystal connected directly between the base and the collector as shown in the schematic.

That's my story. If you want a detailed description of crystal oscillators, several are given below. However, I'll use this circuit for my BFOs from now on. Success at last.

*Crystals for 455 and 453.5 kHz are available from John L. Winton, WD6DUS, 8062 San Meteo Drive, Buena Park, California 90620. Price is $2.50 each.

bibliography

Harrison, Roger, VK2ZTB, "Survey of Crystal Oscillators," *ham radio*, March, 1976.

Nelson, Don, WB2EGZ, "Quartz Crystals: Gems for Frequency Control," *ham radio*, February, 1979.

Ed Marriner, W6XM

easy matching sections

How to design impedance transformers for multi-antenna arrays

In single-antenna applications, using the usual 50-ohm transmission-line system, impedance matching is no problem. However, when multiple antennas are used, the feed system becomes more complex, and impedance transformations become important.

If the antennas in question are of unknown impedance or are known to be reactive, the impedance will have to be reduced to a convenient resistive value by using stubs or other means before they can be fed in an array.[1] If stubs are used in a multi-antenna array, the phasing of the antennas should be checked to ensure that all stubs are alike and are introducing identical phase changes in each line.

In the case of commercial antennas, or those of a known resistive impedance, stubs are unnecessary. However, in dealing with unbalanced coax feed-line systems, any balanced antennas must be fed with baluns.

theory

When using multiple identical antennas with a coax feed system, the necessary impedance transformations are easily handled with 1/4-wavelength sections of rigid coax constructed to give the correct Z_0:

$$Z_0 = \sqrt{Z_{load} \times Z_{feed}} \qquad (1)$$

where Z_0 = characteristic impedance (ohms)

Z_{load} = load point impedance (ohms)

Z_{feed} = feedpoint impedance (ohms)

so that an antenna of 50 ohms attached to a 75-ohm feed system would need a 1/4-wavelength section of:

$$Z_0 = \sqrt{50 \times 75} = 61.24 \text{ ohms} \qquad (2)$$

This coax is not readily available, so it will have to be constructed.

A system developed by Marshal Williams, K5MB, and others, using a square aluminum outer conductor for matching sections is ideal for this unit, and will be used here. In this system the 1/4-wavelength section has an outer conductor of 1-inch square (OD) aluminum tube with either 1/8 inch or 1/16 inch wall thickness.

In this system, with square outer and round inner conductors, the impedance of the coax sections is given by:

$$Z_0 = 141 \log_{10} \frac{b}{a} \qquad (3)$$

where b = OD of inner conductor (inches)
a = ID of outer conductor (inches)

Solving for b in terms of Z_0:

$$b = a \log_{10}^{-1} \left[\frac{Z_0}{141}\right]$$

$$\text{or } b = a \log_{10}^{-1} \left[\frac{\sqrt{Z_{load} \times Z_{feed}}}{141}\right] \qquad (4)$$

This allows us to determine the necessary inner conductor OD for each of the outer tubing wall thicknesses. The handiest combination will be used.

As an example, consider a 25-ohm load matched to a 50-ohm feed line. The Z_0 of this section will be:

$$Z_0 = \sqrt{25 \times 50} = 35.35 \text{ ohms} \qquad (5)$$

Using 1/8-inch thick wall outer stock and this Z_0 we will need a 0.419-inch OD inner conductor. This is an unusual size for tubing, so try the same process with 1/16-inch wall (7/8-inch ID) outer stock. This combination requires a 0.492 inch inner conductor, so we can use standard 1/2-inch OD copper tubing; obviously the easiest choice.

By Jim Pruitt, KL7HIT, Box 2066, San Francisco, California 94126

With this basic construction available, let's look at practical antenna combinations. Impedance matching usually becomes a problem only in multiple antenna systems, which we will assume are composed of even numbers of coax-fed antennas with impedance of 300, 200, 75, or 50 ohms.

network details

Using two 50-ohm antennas, we then have a parallel combination presenting a 25-ohm load to the matching section. This is done by using two parallel connectors on the load end of the matching section (**fig. 1**). As we saw previously, this matching section will use 1/16-inch thick wall outer stock and 1/2-inch OD inner tubing.

Similarly four 50-ohm antennas can be handled as four parallel loads totaling a 12.5 ohm load, **fig.** 2, or as two sections back-to-back forming a 1/2 wavelength matching section, **fig.** 3, which is simply an easier way of building two 1/4-wavelength, 25-ohm to 100-ohm sections. The 100-ohm points are then paralleled to give a 50-ohm point.

Up to four loads may be used on each 1/4-wavelength section — one connector per side — so a 1/2-wavelength section can drive up to eight loads. Matching sections may be used two deep if necessary, as in **fig.** 4.

Table 1 lists the appropriate inner conductor OD for each application. The values are for 50- and 75-ohm antennas and feed systems most commonly used. Other values may be found using the same method, or the antenna may be converted to these values. The velocity of propagation in air dielectric coax such as this is virtually the same as air. Free-space calculations may be used, and the length found by:

$$\lambda/4\ length\ (in.) = \frac{1.808 \times 10^4}{4f_o} \qquad \textbf{(6)}$$

where f_o = operating frequency (Hz).

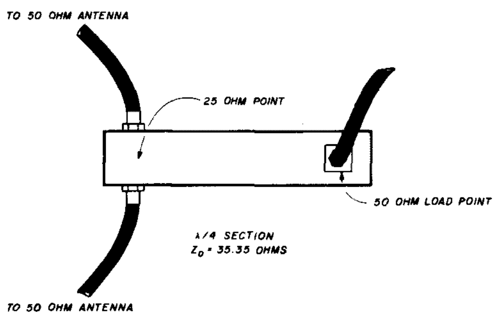


fig. 1. Load end detail with two load connectors.

The value for 145 MHz, for instance, is 31.17 inches. This is the dimension used between connector and center pins. The outer conductor square stock will be cut approximately 1/2 inch longer on each end to accommodate the connector flanges. **Fig. 5** shows the connector mounting details. If more than one matching section is used in a system, make all dimensions identical in all sections to minimize errors.

The feed point in the middle of a 1/2-wavelength section is constructed as shown in **fig. 6**. The load-end construction is identical for 1/2- or 1/4-wavelength designs.

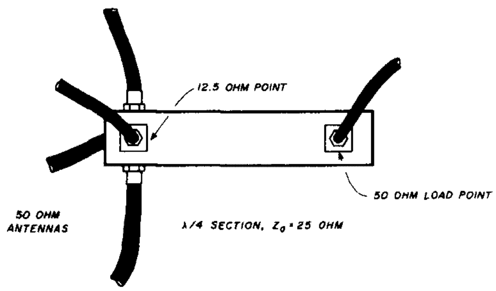


fig. 2. Load end construction showing four loads.

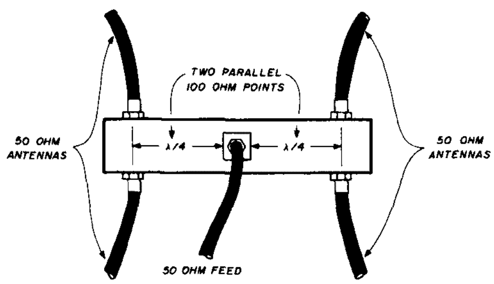


fig. 3. Detail of four load, halfwave construction.

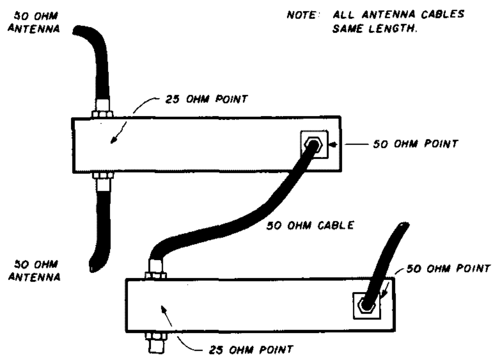


fig. 4. Network using two-deep matching sections.

examples

Now that we have the construction of the individual sections in hand, let's look at some examples. Suppose we want to design a broadside array of sixty-four antennas, with three elements each, for a total of 192 elements. All antennas are balun-fed Yagis of commercial design and present 50-ohm loads to the balun feed points.

There are several possible feed configurations involving different-value matching sections. If we use all identical matching sections, we can work with a design to connect four 50-ohm antennas to a 50-ohm system (see fig. 7). From table 1 we find that 1/8-inch wall square stock and 1/2-inch OD center conductor works very well for this conversion. Using this design throughout we have a network to com-

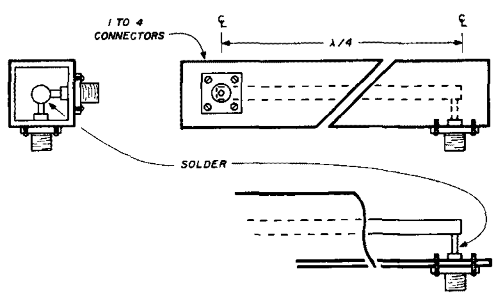


fig. 5. Detail of connector mounting.

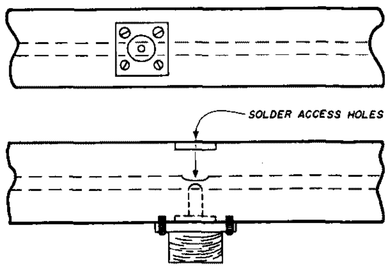


fig. 6. Halfwave feed point connector mounting.

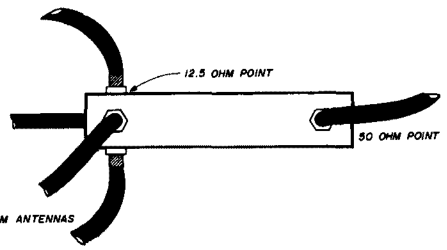


fig. 7. Sixty-four antenna array using all identical matching sections.

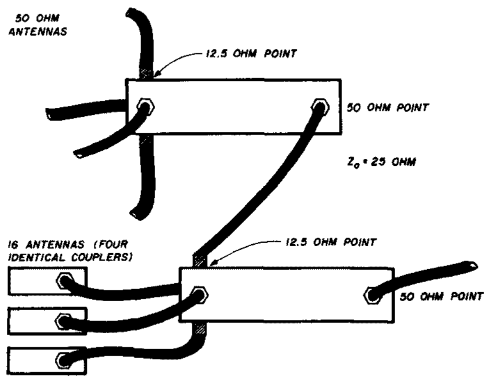


fig. 8. Sixteen 50-ohm antennas matched to a 50-ohm source.

table 1. Inner-conductor OD values for common 50- and 75-ohm antennas and feed lines.

number of loads	using 1/16-in. wall outer stock (in.)		using 1/8-in. wall outer stock (in.)	
1/4 wavelength, 50-ohm antennas to 50-ohm system:				
2	1/2	very good	27/64	
3	35/64		15/32	
4	9/16 SWR 1.04		1/2	very good
1/4 wavelength, 75-ohm antennas to 75-ohm system:				
2	3/8 SWR 1.02		5/16	very good
3	27/64		3/8	very good
4	15/32	very good	13/32	very good
1/2 wavelength, 50-ohm antennas to 50-ohm system:				
2	9/32		15/64	
4	3/8	very good	21/64	
6	7/16 SWR 1.08		3/8	very good
8	1/2	very good	27/64	
1/2 wavelength, 75-ohm antennas to 75-ohm system:				
2	13.6/64	hard to find	4/32	
4	1/4	very good	7/32	
6	5/16	very good	9/32	
8	3/8	very good	5/16	very good
1/4 wavelength, 75-ohm antennas to 50-ohm system:				
2	3/8		0.431	hard to find
3	1/2		0.421	hard to find
4	17/32	hard to find	0.455	hard to find
1/2 wavelength, 75-ohm antennas to 50-ohm system:				
2	0.213	hard to find	3/16	good
4	0.322	hard to find	0.276	hard to find
6	3/8		0.322	
8	7/16 SWR 1.18 not good		3/8 SWR 1.18	

bine 16 antennas into one group that will match a 50-ohm system (**fig. 8**). The addition of three more identical groups, each connected to a port on one last matching section, gives the final configuration of the sixty-four antennas shown in **fig. 9**. Another possibility using a combination of 1/2- and 1/4-wavelength sections in the same array is shown in **fig. 10**.

power division

In an impedance-matching section with two or more loads we, of course, also have a power division occurring. The matching section is interested only in the transformation of total net load impedance to feed line impedance. The power division among the loads is a function of their impedances. If the power to all loads is to be equal, then the load impedances must be equal. Noting that some of the matching sections have other sections as loads, we can see that all antennas must be identical in construction, as must all the similar matching sections. Dimensions must be identical for similar units, so cut all the parts at the same time to ensure uniformity.

phasing

In a large array it is necessary to get maximum power to the antennas through proper impedance management and to have it evenly divided. However, we must also make sure that the rf gets to all antennas at the same time, or in phase. Since we have

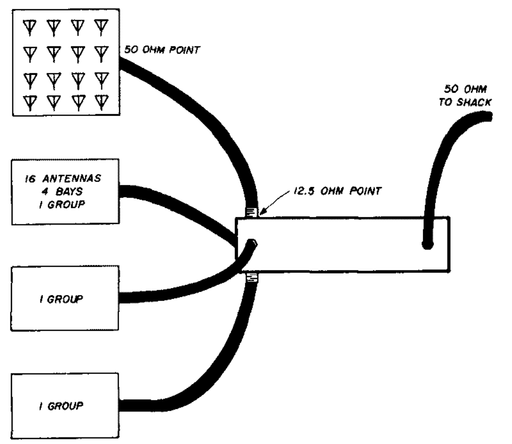


fig. 9. Four of the sixteen antenna arrays combined using one more four-port matching section.

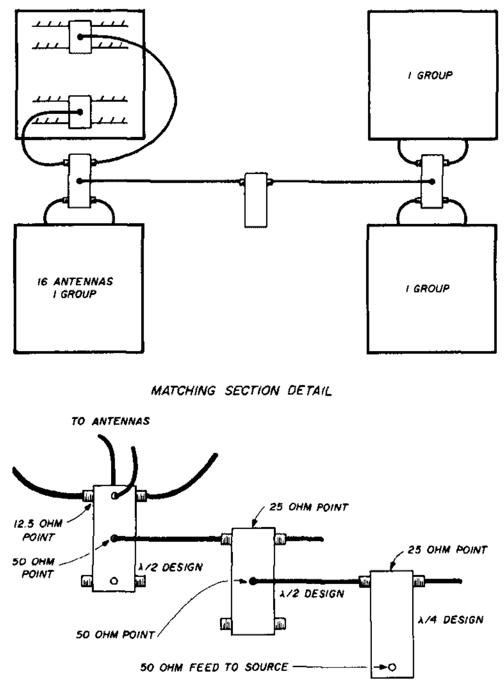


fig. 10. Same array as in fig. 9 but using another matching section combination.

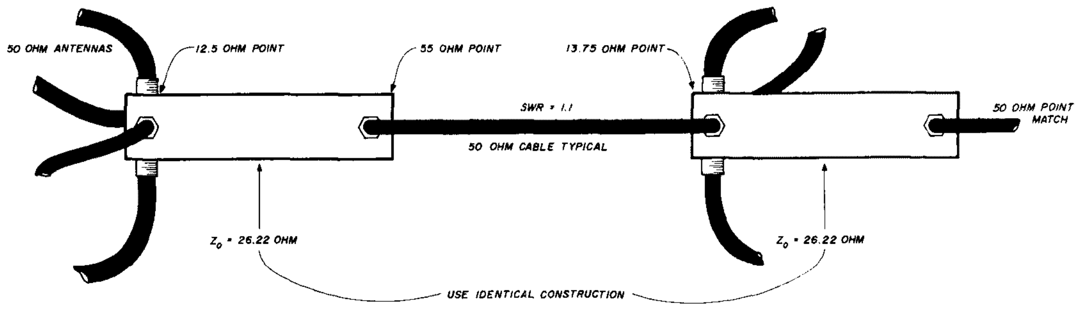


fig. 11. Two identical sections tend to correct their own construction errors.

made all the matching sections equal lengths, and they all have the same air dielectric, the delay to rf traveling through them will all be the same. A good grade of coax for all connecting cables is very important. Care must be taken to make all coax lines in the system the same length as all other lines in the same positions. That is, all coax lines from the antennas to the first matching sections must be the same length. All lines from the first matching sections to the second matching sections must be the same length, but not necessarily the same length the antenna lines were, and so on.

self-correcting features

Another benefit of identical matching sections is the self-correcting feature. If for some reason the transformation is not exactly correct, so that 50-ohm antennas are transformed to, say, 55 ohms by the first matching section, the identical second matching section will correct the situation by transforming the 55-ohm networks back down to 50 ohms to match the drive system (**fig. 11**).

power and precautions

With properly constructed matching sections, the coax portions of the network will be flat with a VSWR near 1.0. The array shown here should present a 50-ohm resistive load with a feed-line VSWR of 1.0 or very close to it.

The impedance-matching sections will carry full legal power with ease provided some basic precautions are taken. It is almost impossible to waterproof everything on these units: rivets, screws, connectors all tend to leak. The best approach is to leave the ends wide open so that the water can drain out and check occasionally for obstructions such as insect nests, leaves, or ice, depending on your location.

materials

Materials are available from several sources. One-sixteenth-inch, 1-inch square aluminum tubing is available from most hobby or building supply stores. Specifically it has been obtained from MacLanburg Duncan Co., 4041 N. Santa Fe, Oklahoma City, Oklahoma 73118. Standard copper tubing sizes are available in rigid form from a plumbing supplier. Some other tubing sizes, usually in brass, are available from large hobby shops. If this is not convenient, contact a nonferrous-metals dealer in a larger city for odd-size tubing and for the 1-inch square, 1/8-inch wall aluminum stock.

reference

1. Jim Pruitt, WB7AUL, "Matching Complex Antenna Loads to Coaxial Transmission Lines," *ham radio*, May, 1979, page 52.

ham radio

a speech processor for fm transmitters

A microphone amplifier and audio processor for fm transmitters using Plessey SL6043 ICs

This article describes a microphone amplifier and audio processor for fm transmitters. It uses a Plessey Semiconductors type SL6043 quad operational amplifier and consists of a high-input-impedance pre-amplifier (which may be omitted if a high-input impedance is not required), an amplifier, a pre-emphasis circuit, and a Sallen and Key lowpass filter.

the Plessey SL6043 IC

The SL6043 (fig. 1) has been especially developed for use in radio applications. The operating current of each amplifier is programmed by an external pin. Pin 8 biases amplifiers B, C, and D, and pin 16 biases amplifier A. It's thus possible to bias one amplifier at a totally different point than the others if desirable in a particular application. The SL6043 may be used in amplifiers, buffers, filters, comparators and voltage regulators.

speech processor circuit

Fig. 2 shows the circuit diagram of the speech processor. It consists of a high-input-impedance, noninverting stage with a gain of 16 dB (x6), a main amplifier with a gain of 38 dB (x80), a pre-emphasis stage with a response rising at 6 dB/octave, and a lowpass Sallen and Key filter with an 18 dB/octave rolloff above 3 kHz. The pre-emphasis stage is arranged to have symmetrical limiting so that it will also serve as a peak clipper.

The input amplifier uses operational amplifier A of the SL6043C in the noninverting mode. Its dc working voltage point is deliberately set at 0.4 Vcc rather than 0.5 Vcc, so that the electrolytic interstage coupling capacitor is correctly biased. This stage has an input impedance of about 400k and a gain of 16 dB (x6). The gain is set by R1 and R2 and may be altered by changing R2 according to

$$gain = \frac{R1 + R2}{R2} \tag{1}$$

The gain of stage A may be varied from unity (R2 omitted) to 26 dB (x20) if R2 is reduced to 27k. This is the minimum recommended value for R2. If more gain is required, it should be added externally.

If a low-impedance dynamic microphone is used, the input amplifier is not necessary and may be omitted. In that case op-amp A may be used for some other purpose. In either case, it may be necessary to detach pin 16 from R3 (fig. 2) — either to power down op-amp A altogether or to power it to a higher level. If the input amplifier isn't used, the input signal is applied at point X, which should also be decoupled to ground by a 0.001-μF capacitor.

The main amplifier is a conventional inverting "see-saw" amplifier. Its gain, which is set by R4, is normally 38 dB (x80), but it may be varied between 20 dB (x10) when R4 = 2.7k and 40 dB (x100) when R4 = 27k. The input coupling capacitor sets the low-frequency rolloff of 6 dB/octave below 300 Hz.

This amplifier, and the one following it, are biased so that any large-amplitude signals are symmetrically clipped. Clipping is essential to ensure that the transmitter does not over deviate on transients. Symmetrical clipping ensures that only odd-order harmonics are present in the clipped signal (third, fifth, etc.);

By James M. Bryant, G4CLF, and Peter E. Chadwick, G3RZP, Plessey Semiconductors Ltd., Cheney Manor, Swindon, SN2 2QW, England

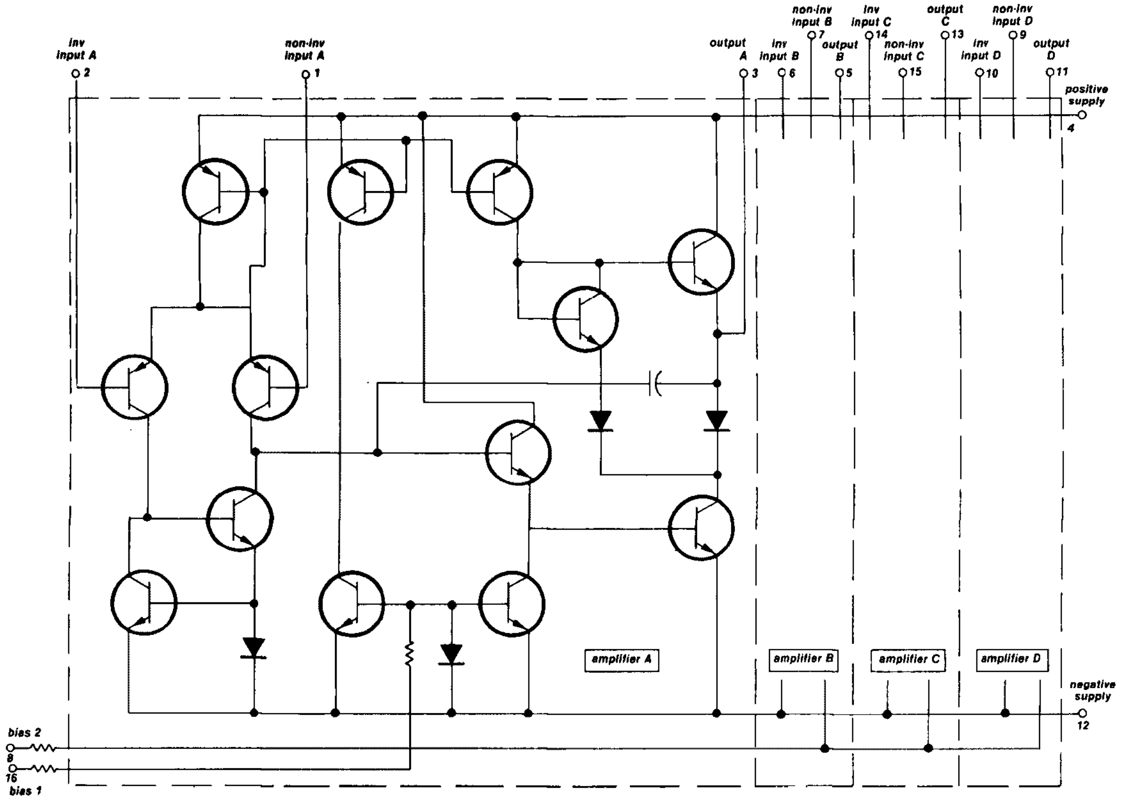


fig. 1. Circuit diagram of the SL6043C quad operational amplifier.

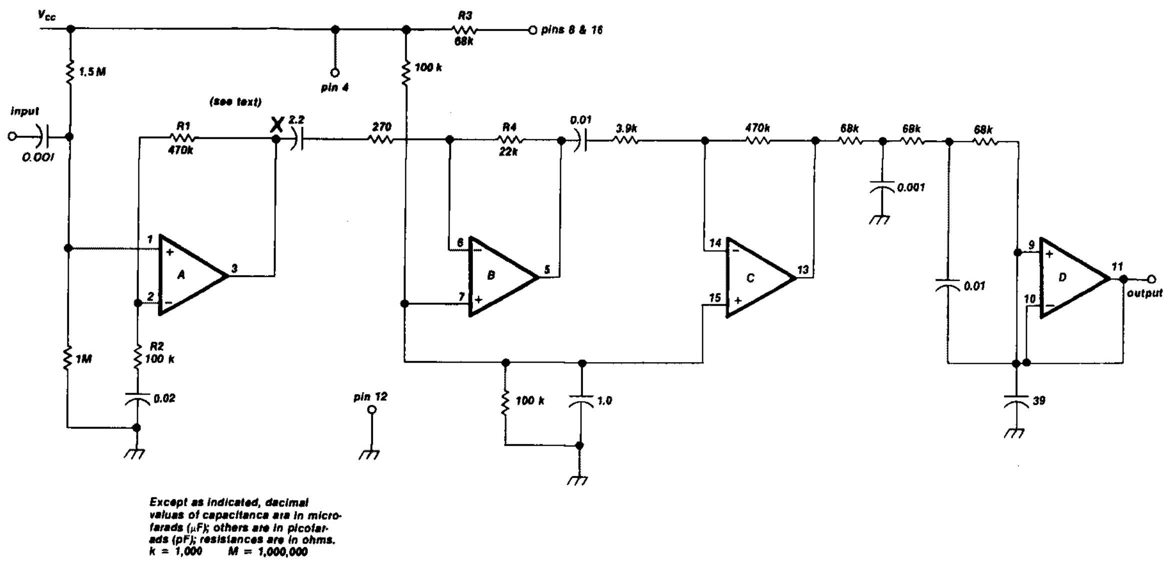


fig. 2. Circuit diagram of the fm speech processor.

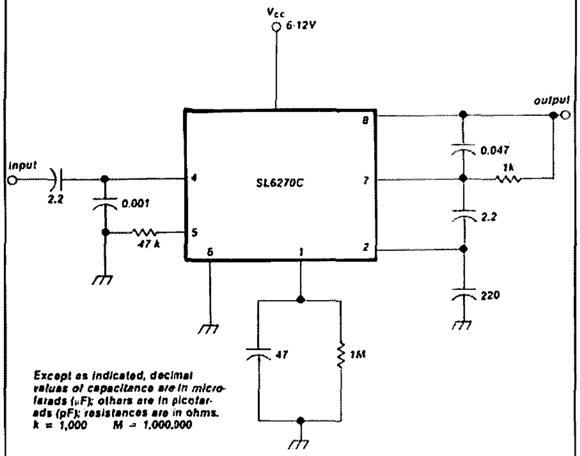


fig. 3. VOGAD using the SL6270C (may be used in place of the input stage if audio AGC is required).

they are less unpleasant and, being higher in frequency, more easily filtered than the second harmonic, which would result from asymmetrical clipping.

The third stage is another inverting see-saw amplifier; but the input half of the see-saw, consisting of 0.01 μF in series with 3.9k, is capacitive up to 4 kHz and gives a rising 6 dB/octave response up to this frequency. This stage is the one most likely to limit.

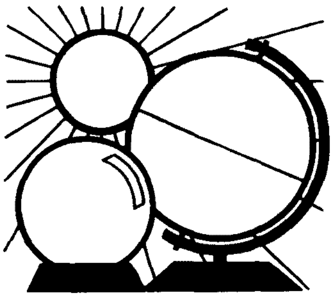
The signal from the pre-emphasis circuit goes to a third-order Sallen and Key lowpass filter, which gives an 18 dB/octave slope above 3 kHz. This filter consists of three capacitors, three resistors, and op-amp D, which is used in the unity gain, noninverting mode.

The output level from the system depends on the input level and the gain since no AGC is used (if audio AGC is required, the input amplifier should be replaced with the Plessey Semiconductors SL6270 VOGAD, used in the circuit shown in **fig.** 3, and R4, **fig. 2**, should be 5.6k). The gain of the first two stages should be set so that the output level is around 1.5-2 VRMS with normal speech into the microphone. This ensures a reasonable, but not excessive, level of clipping.

The power supply is a single + 12 V unit, but this is not critical and may be varied from +6 to +24 V without any effect but a change in the clipping level. The supply should, however, be well decoupled from audio and radio-frequency energy.

No printed circuit board has been designed for this system, because it's so simple that it's likely to be used in many widely different applications. No special precautions are needed in construction except to isolate the high-impedance input from the output and, if it contains hum, to isolate the power supply.

ham radio



DX FORECASTER

Garth Stonehocker, K0RYW

last-minute forecast

The higher-frequency ham bands during daylight hours will offer the best DX for the first week and a half of the forecast period. Solar flare activity is expected to result in solar wind bursts of particles that disturb the magnetosphere and ionosphere. Disturbed periods are probable around the 7th, 15th, and 23rd of the month. Signals on east/west paths through high latitudes will be weak and suffer from QSB, while trans-equatorial north/south paths will be enhanced. Low-band DX should be very good all through the month, particularly trans-polar paths at twilight during geomagnetically quiet times. The moon will be full on March 9 and perigee on March 4 and 29.

In March and April spring storms bring rain to much of our country. From these storms come the year's first major thunderstorms — and thunderstorms mean noise (static). Increased noise lowers the signal-to-noise ratio in our receivers, decreasing readability. This brings to mind the old saying, If you can't hear 'em, you can't work 'em. Last year's March issue of *ham radio* went into how noise gets here and how to track it. You can schedule your DXing in between storm passages to get the best chances of hearing the weak ones.

Toward the end of March (associated with the equinox, which is on March 20 at 2256 UT), the geomagnetic field is easily disturbed. The equatorial plane of the sun lines up through space with the earth's equator, giving particles a more direct path to the earth's polar regions. Disturbances are common. DX can be from unusual locations because of the ionosphere's erratic movements. East/west paths are generally poorer; otherwise, over-the-pole DX paths are best during the equinox season.

I've mentioned beacons several times in the past. A beacon is a transmitter which generally operates full time. It is identifiable by its frequency, modulation, or call sign. By listening for the beacon you can ascertain if the band is open to that location. Beacons can be intentionally set up by Amateurs, or it's possible to eavesdrop on the transmitters of other services on frequencies adjacent to an Amateur band. Even a megahertz or two away is close enough to give you an idea of the propagation conditions on the band in question.

One group of signals that make useful beacons are the standard frequency and time stations on 2.5, 5, 10, 15, and 20 MHz. There are some twelve different countries represented, with a total of nine beacons on 2.5 MHz, eleven on 5 MHz, nine on 10 MHz, seven on 15 MHz, and two on 20 MHz. Canada and Australia broadcast three frequencies each near these.

beacons on 2.5, 5, 10, and 15 MHz

The following stations may be used as beacons on the WWV frequencies: BPM, China; JJY, Japan; WWVH, Hawaii; WWV, Colorado; MSE, England; IBF, Italy; LOL, Argentina; ZUO, South Africa; and RTA, Russia. If you've heard some peculiar sounds with the WWV signals while you've waited to check the daily solar flux and geomagnetic data at eighteen minutes after the hour, it may have been one of these other signals on the frequency "interfering." Maybe that's not so bad: after you ferret them out, you can use them for determining propagation conditions and openings.

By knowing the broadcast and modulation schedule of each station, you can tell which one is which. Here are a couple of examples: WWV is a man's voice and WWVH a woman's voice, giving the time each minute (ladies first); China identifies BPM in Morse during the one minute preceding the hour and half hour. For information on all these stations and their services consult the CCIR Working Group 7-C Draft report on 267-4 (MOD F), which may be obtained from Mr. R. Beehler, National Bureau of Standards, 325 Broadway, Boulder, Colorado 80301.

band-by-band summary

Six meters will provide some excellent openings to South Africa from the eastern U.S. and from the western and central U.S. to Australia and New Zealand around local noon. The openings are more probable during periods of high solar flux values.

Ten, fifteen, and twenty meters will be full of signals from most areas of the world from morning into early evening almost every day. The openings will be shorter on the higher bands and concentrated more toward noon for the path of interest. High solar flux values and geomagnetic disturbances will favor these bands for trans-equatorial contacts. Noise effects are not too noticeable.

Forty, eighty, and one-sixty meters are the night DXer's bands. The bands open just before sunset and last just until the sun comes up on the path of interest. Except for daytime short-skip signal strengths, high solar flux values don't affect these bands much. Geomagnetic disturbances, however, which will be more evident near the equinox, cause much signal attenuation and fading on polar paths. Noise will be spasmodic and very noticeable on these lower-frequency bands.

ham radio

MARCH

WESTERN USA

GMT	2300	2200	2100	2000	1900	1800	1700	1600	1500	1400	1300	1200	1100	1000	0900	0800	0700	0600	0500	0400	0300	0200	0100	0000	
PST	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	
ASIA FAR EAST	10	10	—	—	—	15	15	20	20	20	20	20	20	20	20	20	—	—	—	10	10	10	10	10	N
EUROPE	20	20	20	20	10	10	15	15	20	20	20	40*	—	—	—	—	—	—	40	40	20	20	20	20	NE
S. AFRICA	10	10	10	10	10	10	15*	15	15	15	—	—	—	—	20	20	20	20	20	20	15	15	10	10	E
S. AMERICA	15	10	10	10	10	10	10	10	10	10	15	15	20	20	20	20	15	15	15	15	10	10	15	15	SE
ANTARCTICA	10	10	10	15	15	15	—	—	—	—	—	20	20	20	20	20	20	15	15	15	10	10	10	10	S
NEW ZEALAND	10	10	10	10	10	15	15	15	20	20	20	20	15	15	15	15	15	10	10	10	10	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10*	10	—	—	—	15	15	20	20	20	20	15	15	15*	10	10	10	10	10	10	10	10*	W
JAPAN	10	10	15	20	20	20	20	20	20	20	20	20	—	—	—	—	20	20	20	20	15	15	15	10	NW

MID USA

MST	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	
ASIA FAR EAST	15	—	—	15	15	15	15	15	15	20	20	—	—	—	—	—	—	—	15	15	15	15	10	10	N
EUROPE	20	20	20	15	15	10	10	10	10	15	15	20	20	20	—	—	—	—	40	40	40	40	20	20	NE
S. AFRICA	10	10	10	10	10	10	10	10	10	10	15	—	—	—	20	20	20	20*	20	20	15	15	15	15	E
S. AMERICA	10	10	10	10	10	10	10	10	15	15	15	20	20	20	20	20	20	15	15	15	15	10	10	10	SE
ANTARCTICA	10	10	10	10	15	15	15	15	—	—	—	—	20	20	20	20	20	20	15	15	15	15	15	10	S
NEW ZEALAND	10	10	10	10	10	10	15	15	15	15	20	20	20	20	20	15	15	15	15	15	10	10	10	10	SW
OCEANIA AUSTRALIA	10*	10	10*	10*	—	—	—	15	15	20	20	20	20	20	20	15	15	15	15	10	10	10	10	10	W
JAPAN	10	10	15	—	—	—	—	20	20	20	—	—	20	20	20	20	20	20	20	15	15	15*	10	10	NW
CST	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	

EASTERN USA

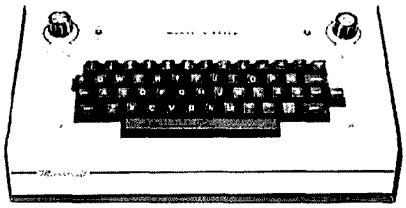
EST	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	6:00	5:00	4:00	3:00	2:00	1:00	12:00	11:00	10:00	9:00	8:00	7:00	
ASIA FAR EAST	15	15	—	—	—	—	—	15	15	15	—	20	20	20	—	—	—	20	20	20	15	15	10	10	N
EUROPE	20	20	20	15	15	15	10	10	10	10	10	15	20	20	20	40	40	40	40	40	20	20	20	20	NE
S. AFRICA	15	15	10	10	10	10	10	10	10*	10*	10	10	15	—	—	—	20	20	20	20	20	15	15	10	E
CARIBBEAN S. AMERICA	10	10	10	10	10	10	10	10	10	10	10	15	20	20	20	20	20	15	15	15	15	15	15	10	SE
ANTARCTICA	10	10	10	10	10	15	—	—	—	—	—	—	20	20	20	20	20	20	20	15	15	15	15	15	S
NEW ZEALAND	10	10	10	10	10	15	15	15	20*	—	—	20	20	20	20	20	20	20*	20*	15	15	10	10	10	SW
OCEANIA AUSTRALIA	10	10	10	10	—	—	—	20	15	15	15	20	20	20	20	20	20	20	20	20	15	15	10	10	W
JAPAN	15	15	15	15	—	—	—	—	—	—	—	—	—	40	40	40	20	20	20	15	10	10	10	10	NW

*Look at next **higher** band for possible openings.

NEW products

Morse-A-Keyer

A low-cost, dependable CW keyboard is now available from Microcraft. It features an industrial quality keyboard, rugged steel case, and a 16-character first-in first-out buffer which allows you to type slightly



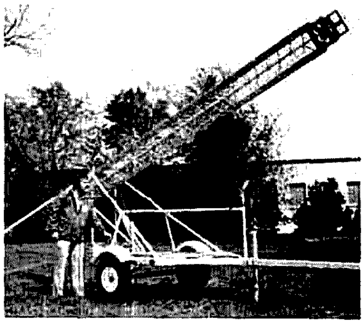
ahead of the text being sent. Also included are an internal speaker, sidetone monitor, and buffer full LED.

Speed range is 5 to 45 WPM standard, but can be easily increased by changing one resistor. A reed relay is used to key your transmitter and to provide isolation between the keyboard and associated equipment.

The Morse-A-Keyer is available as a partial kit, complete kit, or factory wired and tested. The partial kit consists of a PC board, construction manual and board parts. The builder must supply an ASCII coded keyboard, 5 volts at 120 mA supply and miscellaneous hardware. Cost is $69.95 plus $3.00 shipping and handling. The complete kit sells for $159.95 plus $5.00 shipping and handling and the factory wired model for $205.00 plus $5.00 for shipping and handling. Write Microcraft Corporation, P.O. Box 513, Thiensville, Wisconsin 53092.

trailered towers

Trailer-mounted antenna towers can be erected by a single person in record time. From the time the trailer



was parked, to the full extension of the Telex/Hy-Gain tower, only 15 minutes had passed. These self-supporting, crank-up steel towers are easily trailered even by passenger cars. The trailer towers are exceptionally well suited to microwave tower surveys, their construction or repair, for site evaluation of two-way radio repeaters, for emergency or security field communications for remote a-m, fm or TV broadcasts at special occasions such as large outdoor concerts, fairs or sports events, or can be used as temporary light-support systems.

Towers are mounted on the trailer by a method which requires only one winch to tilt and erect the tower to its full height. Single-axle trailers, complete with legal running lights, accommodate medium to heavy-duty towers to 52 feet (15.85 m). Two axle heavy-duty trailers with towers to 70 feet (21.3 m) are also available. Antenna rotators, winch motors, and other accessories are optional.

For full information contact Clyde Blyleven, Hy-Gain, Division of Telex Communications, Inc., 8601 N.E. Highway Six, Lincoln, Nebraska 68505.

440-MHz synthesized handheld

Encomm, Inc., announces the addition of the ST-7/T 440-MHz synthesized handheld transceiver for use in the 440-449.995 MHz band to the Santec line of handheld radios.

This compact UHF package has a nominal 3 watts output from the transmitter and incorporates all 16-tone DTMF tones and optional synthesized CTCSS encoder capability. The high power level is backed up by the ability to switch to either one watt or as low as 50 milliwatts for battery saving applications.

The styling of the ST-7/T is quite similar to that of the popular Santec HT-1200 2-meter unit. All of the external accessories for the 2-meter unit are compatible with the ST-7/T. Both the receiver and transmitter cover the full band of 440 fm to provide true universal compatibility with the ARRL band plan for 440 MHz. Offset of the transmitter from the dialed receiver frequency is accomplished at the flick of a three-position switch, which provides for direct operation on the same frequency and up or down 5 MHz for the standard repeater offset. Another switch feature is the immediate access to the national calling frequency of 446.000 MHz (SPX) by actuating a single slide switch. The ST-7/T features a micro-thumbwheel frequency

selector switch to provide positive readout and control of the CMOS PLL synthesizer plus a metalized center body to provide better antenna efficiency. The antenna is a full 1/4-wave flex antenna which mounts on the BNC connector.

For more information, contact Encomm, Inc., 2000 Avenue G, Suite 800, Plano, Texas 75074, or telephone (214) 423-0024.

COMM-X antennas

"COMM-X," "Communications Extender," series of antennas presently includes two models. The model CX-144 has a frequency of 144-148 MHz and is 52 inches in length; the model CX-220 is 35 inches long and has a frequency of 220-225 MHz.

Both feature adjustable whips designed to allow field tuning for optimum VSWR, typically 1.5:1 or less at resonance, and typical gain of 3 dB over a 1/4-wave standard. In addition, two stainless steel set screws secure the heavy-duty whips to provide "double-locked" protection. The ferrule is attached with adhesive and also mechanically staked to ensure integrity.

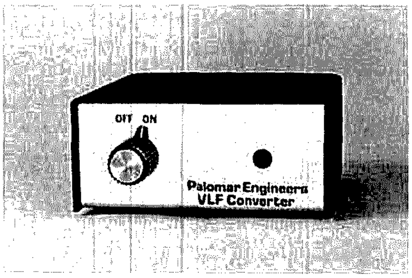
The "COMM-X" is rated at 200 watts and is made of quality materials, including 17-7 taper ground stainless steel whip, 16-gauge copper matching coil, and standard 3/8-24 chrome-plated brass base. This combination provides excellent wear resistance for long-lasting service.

Valor Enterprises, Inc., is located in West Milton, Ohio. Additional information may be obtained by writing or calling (513) 698-4194; outside Ohio call toll free: (800) 543-2197.

vlf converters

Palomar Engineers is introducing two new converters for the 10-500 kHz band. They add to shortwave receivers reception of weather, ship-to-shore CW traffic, RTTY, WWVB, navigation beacons, 1750-meter no-license band, and European low-frequency broadcast stations.

Model VLF-A converts to 3510-4000 kHz for use with ham-band-only



receivers and transceivers. This gives optimum reception, since receiver noise figure is best on 80 meters.

Model VLF-S converts to 4010-4500 kHz for general coverage shortwave receivers. With digital readout the last three digits read frequency directly.

The new converters feature antenna bypass when turned off, LED power indicator, and low-current 9-volt dc operation. They are housed in attractive brushed aluminum and black vinyl cabinets.

The new converters sell for $79.95. For further information write Palomar Engineers, 1924-F W. Mission Rd., Escondido, California 92025.

portable RTTY/CW terminal

HAL Communications Corporation announces the new CWR685A Telereader portable RTTY/CW terminal. Featuring compact size and 12-Vdc operation, the CRW685A is just the thing for the traveling RTTY Amateur. A green phosphor 5-inch display is built into the small 12-3/4 × 11 × 5 inch main cabinet, as is an RTTY modem for three shifts, both high and low tones. The keyboard is separate and connects with a 3-foot cord to the main unit. Advanced features such as programmable HERE IS messages, type-ahead transmit buffer, and automatic transmit/receive control are included with the Telereader.

NEW products

The CWR685A can easily be slipped into a suitcase for a ham-holiday outing. In the home shack, the Telereader consumes little space and can be connected to an external monitor and parallel ASCII printer for even more versatility. For more information, contact HAL Communications Corporation, Box 365, Urbana, Illinois 61801.

handheld synthesized scanner

Electra Company has announced a breakthrough in scanning radios with their new Bearcat® 100 handheld portable, which they will manufacture here in the U.S. Fully synthesized, it requires no crystals. Compressed into a 3 × 7 × 1¼ inch case is more scanning power than in many base or mobile units. The unit has a full 16 channels with extended frequency coverage. Power consumption is kept extremely low by using a liquid crystal display and several low-power integrated circuits which are new to the industry.

The Bearcat 100 produces audio power output of 500 milliwatts and a hefty one full watt when used in conjunction with the accessory ac adapter included in the package. The unit has patented Track Tuning, selectivity of better than 50 dB down, and sensitivity of less than a microvolt on all bands and all channels.

The unit operates on six AA batteries and has a battery-low LED indicator to signal when to recharge. A special internal circuit protects against overcharging while also preventing excess drain on the batteries. The unit's wide frequency coverage includes all public service bands (low, high, UHF, and T bands), both 2-meter and 70-centimeter Amateur bands, plus military and federal land mobile frequencies. The unit has direct channel access and a built in automatic scan delay.

The package includes a sturdy carrying case, earphone, battery charge/ac adapter and has a suggested retail price of $449.95. Complete details are available from Bearcat scanner suppliers, or by writing to Electra Company, 300 East County Line Road, Cumberland, Indiana 46229.

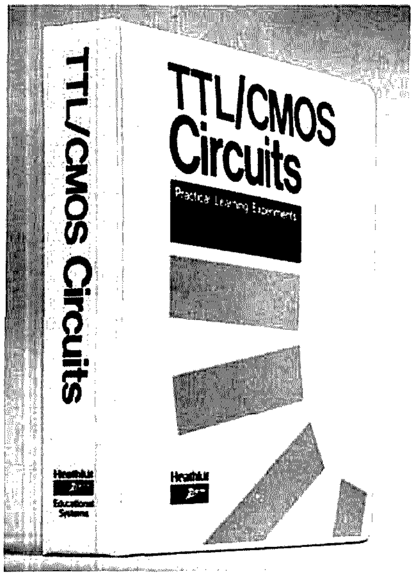
2-meter fm transceiver

Trio-Kenwood has just introduced a new 2-meter fm mobile transceiver, the model TR-7730. The compact TR-7730 has an rf output power of 25 watts, with HI/LO power switch, five memories, memory scan, automatic band scan, up/down manual scan on the microphone, four-digit LED frequency display, S/rf bar meter, ± 600 kHz offset switch, and LED indicators for BUSY, ON-AIR, and REPEATER.

Optional accessories include the MC-46 sixteen-button autopatch microphone, SP-40 remote speaker, and KPS-7 power supply for fixed station operation. For additional information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

course in TTL and CMOS

A new "hardware-oriented" course in TTL and CMOS circuits is being offered by Heathkit/Zenith Educational Systems. Designed for the electron-



ics student, experimenter, Radio Amateur, or computer enthusiast, these concise circuit descriptions are ideal for the person who wants to learn by doing.

A hardware-oriented course designed to give hands-on experience, the TTL and CMOS Circuits Course is composed of a series of circuit files arranged in a logical progression. Each file provides the student with a description of the particular circuit and its operation, a circuit schematic, and modifications that can be performed on the basic circuit.

Text reading is condensed and the course places emphasis on actual circuit construction. Examples of the circuits the student will build (components are included) are seven-segment digital displays, flip-flops, clock generators, data selector distributors, and comparators.

For more details on the EH-702 TTL and CMOS Circuits Course, see the latest 104-page Heathkit Catalog. For a free copy write Heath Company, Dept. 350-165, Benton Harbor, Michigan 49022.

multi-purpose rf wattmeters

Bird Electronic Corporation's line of RF Power Analyst™ directional wattmeters has been expanded by the addition of seven new models. These microprocessor-based digital THRULINE® wattmeters are available now as rack-mounted as well as portable instruments, with built-in or external coax line sections, and with measurement parameters geared to fm, a-m, SSB/DSB, CW, TV or 2-way communications signals.

In addition to bi-directional power from 0.5 to 2300 MHz and from 100 milliwatts to 250 kW, the new series of RF Power Analyst™ instruments measure VSWR, return loss, percent of modulation, dBm and peak envelope power functions. A min/max memory of any displayed quantity makes equipment adjustments simpler than with an analog device.

Detailed specifications in bulletin PA4382-87/1. Price $500-$850, Plug-in Elements $46-$100. Delivery 4-6 weeks ARO. Contact Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139.

200-watt CAP transceiver

The 200-watt solid-state Civil Air Patrol transceiver, Ten-Tec Model CAP 100, has eight crystal controlled channels (two user-selected 4-MHz channels for primary and alternate frequencies plus the National Emer-

NEW products

gency Frequency, two CAP channels on 7 MHz, and the 11.9, 14.9, and 20.8 MHz CAP channels) all built-in. Other features include automatic sideband selection, four-pole crystal ladder filter (2.7:1 shape factor, 6/50 dB), built-in squelch, S/SWR meter, adjustable threshold ALC and drive, clean audio, high-stability oscillators, built-in speaker, built-in phone patch jacks, linear T/R control relay, counter output jack, and 13-volt dc circuitry.

Options include eight-pole plug-in filter, power supply, microphone, noise blanker, mobile mount, mobile circuit breaker, speech processor, and antenna tuner. Styling is in rich bronze with contrasting nomenclature for easy reading. The "clamshell" type aluminum case in dark finish features full shielding, tilt-up bail, and compact size: 5 × 11-3/8 × 12-1/8 inches.

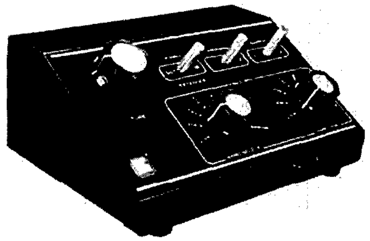
The unit, a basic high-frequency SSB transceiver, can be adapted to domestic and foreign commercial applications as well. Model 100 is priced at $595 with all crystals included. For full information, write Ten-Tec, Inc., Highway 411 East, Seiverville, Tennessee 37862, or telephone (615) 453-7172.

10 kHz-30 MHz tuner

This advanced Signa/Match frequency-selective tuner from Grove Enterprises is designed to optimize impedance matching between any antenna and any receiver on any frequency between 10 kHz and 30 MHz. It will reduce, and in many cases remove, receiver intermodulation, images and front-end overload. Background noise is reduced. Vlf signals you never dreamed were there come roaring in loud and clear.

Front-panel switches allow instant selection between two antennas and between two receivers (or two antenna inputs to one receiver). Matched rotary switches permit the listener to peak signal strength of the frequency of interest, while a main tuning dial provides sharp resolution of the final signal.

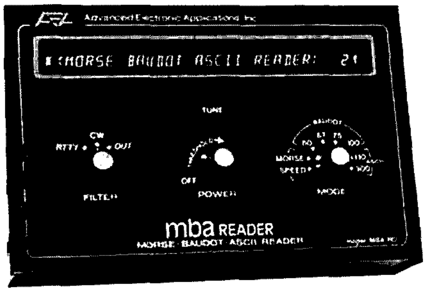
The Signa/Match works best with 50-100 foot wire antennas or center-fed dipole antennas. Signa/Match requires no power source. Installation is between your antenna input line and receiver. Signa/Match comes com-



plete with instruction manual and all interconnecting cables. For further information and free catalog, contact Grove Enterprises, Inc., Dept. D, Brasstown, North Carolina 28902.

MBA™ reader only

AEA, Inc., announces a new reader for Morse, Baudot, and ASCII operation. The MBA-RO (reader only) is a state-of-the-art device using a 32-character vacuum fluorescent alphanumeric display. The 32-character



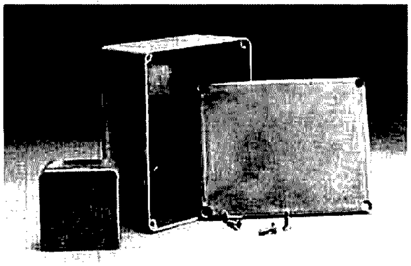
display allows for up to five words to be displayed at one time. This extended display is especially useful during high speed copy.

The equipment features include speed capabilities of up to 99 WPM for CW copy, 60, 67, 75, and 100 WPM for Baudot, and ASCII at 110 and hand-typed 300 baud. The MBA incorporates automatic speed tracking, ensuring no loss of copy due to rapid speed changes in signal reception. The MBA required a 12-Vdc external power supply, making it ideally suitable for portable, mobile, or fixed operation. The MBA is compact in size and can be used with a hand key, bug, or electronic keyer.

For more information, contact Advanced Electronic Applications, Inc., P.O. Box 2160, Bldg. O&P — 2006-196th SW, Lynnwood, Washington 98036, or telephone (206) 775-7373.

diecast boxes

Hammond has introduced a new line of improved diecast aluminum alloy boxes. Good rf shielding makes smaller sizes excellent for rf connectors. The countersunk lid has an interlocking flange and the box is drilled and tapped for screws provided.



The boxes have an attractive ground and tumbled finish which may be painted if required. Quantity discounts provided when ground and tumbled surface not required. These boxes are available at all Hammond distributors or we'll send a free catalog on request. Contact Hammond Manufacturing Company, 1690 Walden Avenue, Buffalo, New York 14225.

MICROWAVE CONVERTERS, decoders. Catalog 20¢. G.W. Electronics, P.O. Box 688, Greenwood, Indiana 48142.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

2 METER EME NEWSLETTER. For 2 meter moonbounce enthusiasts. SASE for free monthly publication. WB7DTI, 426 N.E. 156th, Seattle, WA 98155.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, Learning the Code; Tape #4, Breaking the Speed Barrier; Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

CORDLESS TELEPHONES — Low prices, all major brands. Inquiries or Visa/MasterCard orders call (206) 743-3977 or Write Trinetics, Box 6005, Lynnwood, WA 98036.

Coming Events

ACTIVITIES

"Places to go..."

CALIFORNIA: Orange County Hamfest, March 6 & 7, Orange County Fairgrounds, Costa Mesa. Admission: $2.50 per person; children under 12 free. Auction, DX and CW contests; speakers; children's games; magic show. Western chicken barbeque Saturday, $5.95 pp. Talk in on 147.69, out on 147.09. For information write: Cataline Amateur Repeater Association, P.O. Box 2197, Westminster, CA 92683.

PLAYBOY CLUB: Plan ahead now to attend the ARRL Hudson Division Convention, October 30-31, 1982, at the Playboy Club, Great Gorge, McAfee, NJ. For info send SASE to HARC, Box 528, Englewood, NJ 07631.

CONNECTICUT: The Hartford County Amateur Radio Association's annual auction of used equipment and "stuff", March 11, 7:30 PM, Veterans Memorial, Sunset Ridge Drive, East Hartford. Refreshments served.

FLORIDA: The Playground Amateur Radio Club's 12th annual Swapfest, Saturday, March 20, 8 AM to 4 PM, and Sunday, March 21, 8 AM to 3 PM, Okaloosa County Fairgrounds, Fort Walton Beach. All inquiries, reservations, etc: PARC, c/o Joe Giangrosso, 304 Chickasaw Circle, Fort Walton Beach, FL 32548.

ILLINOIS: The Civil Air Patrol's second annual Spring Hamfest, Saturday, March 20, Lake County Fairgrounds, US 45 & IL 120, Grayslake. Donation: $2.00; tables, $3.00. Reservations and info: SASE Captain Rehm, 637 Emerald St., Mundelein, IL 60060.

INDIANA: The Randolph Amateur Radio Association's third annual Hamfest, Sunday, March 14, 8 AM to 5 PM. Tickets: $2.00 advance; $3.00 door. Guaranteed reservations by advance payment only. R.A.R.A., P.O. Box 203, Winchester, IN 47394 or W9VJX (317) 584-9361. Talk in on 147.90-30.

LOUISIANA: The 22nd annual Lafayette Amateur Radio Hamfest, sponsored by the Acadiana Amateur Radio Association, Saturday, March 13 and Sunday, March 14, Evangeline Downs Racetrack Club House, off Hwy. 167, 5 miles north of Lafayette. For information: AARA, P.O. Box 51174, Lafayette, LA 70505.

MARYLAND: The Baltimore Amateur Radio Club's Greater Baltimore Hamboree and Computerfest, Sunday, March 28, Maryland State Fairgrounds Exhibition Complex, Timonium. Indoor flea market, outdoor tailgating, Amateur radio, personal computer, small business computer displays. Cash grand prizes, hourly door prizes, food service, free parking. Doors open 8 AM. Admission: $3.00. Talk in on 34/94 and 07/67. For information, table reservations: G.B.H. & C., P.O. Box 95, Timonium, MD 21093. (310) 561-1282. For recorded announcement: (301) HAM-TALK.

MASSACHUSETTS: The Framingham Amateur Radio Association's 6th annual Spring Flea Market, the largest Ham flea market in New England, Sunday, April 4. Doors open 10 AM. Admission $2.00. Sellers $8/table (prior to

March 27; $10/table after that). Talk in on 75/15 and 52 direct. Radio equipment, computer gear, food, bargains. Contact Ron Egalka, K1YHM, 3 Driscoll Drive, Framingham, MA 01701. (617) 877-4520.

MICHIGAN: The Southern Michigan ARS and Calhoun County Repeater Association's 21st annual Michigan Crossroads Hamfest, March 20, Marshall High School, Marshall. Doors open 7 AM for exhibitors; 8 AM for buyers/lookers. Refreshments available. Talk in on 07/67 and 52. For information: SMARS, P.O. Box 934, Battle Creek, MI 49016 or call Earl Goodrich (616) 781-3554.

MINNESOTA: The Rochester Amateur Radio Club and the Rochester Repeater Society's Hamfest, Saturday, April 3, John Adams Junior High School, 1525 N.W. 31 Street, Rochester. Doors open 8:30 AM. Large indoor flea market, prize raffles, refreshments. Talk in on 146.22/82. For further information: RARC, c/o WB0YEE, 2253 Nordic Ct. N.W., Rochester, MN 55901.

MISSOURI: A.R.C.H. '82, sponsored by the Gateway Amateur Radio Association, March 27 and 28, Chase Park-Plaza Hotel, St. Louis. Amateur Radio and computer hobbyists. Giant indoor flea market, major exhibitors/dealers; workshops and forums. Saturday evening banquet, ladies' activities. Thousands of $$$ in prizes. Advance tickets $3.00. Gateway ARA, P.O. Box 8432, St. Louis, MO 63132. (314) 361-4965.

MISSOURI: The PHD Amateur Radio Association's 13th annual Northwest Missouri Hamfest and the 1982 Missouri State ARRL Convention, Saturday and Sunday, April 3 and 4, Trade Mart Building at Downtown Kansas City Airport. Over $3500 in prizes. Doors open 10 to 5:30 both days. Forums, ARRL, DX, contest, technical antenna, YL, XYL. Saturday nite banquet at world famous Gold Buffet. Guest speakers: Ellen White, W1YL, DX editor of QST; Marge Tenney, WB1FSN, Convention Coordinator, ARRL; Paul Grauer, W0FIR, ARRL Midwest Director. Registration $4.00. Banquet tickets $10.25. Talk in 146.34/.94. For information/preregistration: PHD Amateur Radio Association, P.O. Box 11, Liberty, MO 64068-0011. (816) 781-7313 or (816) 452-9321.

MISSOURI: The Jefferson Barracks Amateur Radio Club's annual auction and Hamfest, March 12. NEW location, Carondelet Sunday Morning Athletic Club, South St. Louis. For information: Jefferson Barracks ARC, K0ZFK.

NEBRASKA: The 3900 Club and the Sooland Repeater Association's 6th annual Hamboree, Friday, March 19 and Saturday, March 20, Marina Inn, South Sioux City. Doors open Friday noon and Saturday 9 AM. Technical programs, ARRL forum, special Novice meeting, two CW contests, displays of latest equipment. Prize drawings all day Saturday and at banquet. Special exhibits by ARRL, QSL Bureau, Handi-Hams, 3900 Club and Sooland Repeater Association. Special programs for the ladies all day Saturday. Saturday evening at 5 PM entertainment by the North High School Jazz Band followed by banquet at 6. For table reservation contact: Al Smith, W0PEX, 3529 Douglas St., Sioux City, IA 51104. Advance tickets and motel reservations: Jerry Smith, W0DUN, Box 14, Akron, IA 51101. For further information: Dick Pitner, W0FZO, 2931 Pierce St., Sioux City, IA 51104 or Glen Holder, K0TFT, RR 1, Hinton, IA 51024.

NEW JERSEY: The Delaware Valley Radio Association's annual flea market, Sunday, March 28, 8 AM to 4 PM. New Jersey National Guard 112th field artillery armory, Eggerts Crossing Road, Lawrence Township. Advance registration $2.50, $3.00 door. Indoor/outdoor flea market, door prizes, raffles, refreshments, FCC exams. Sellers bring own tables. Talk in on 146.52 and 146.07-.67. For further information: D.V.R.A., P.O. Box 7024, West Trenton, NJ 08628.

NEW JERSEY: The Chestnut Ridge Radio Club's Ham Radio Flea Market, Saturday, March 20, Education Building, Saddle River Reformed Church, East Saddle River Road and Weiss Road, Upper Saddle River. Tables: $10.00 for first; $5.00 each additional. Tailgating: $5.00. Food and soda. Free admission. Contact: Jack Meagher, W2EHD, (201) 768-8360. Neil Abitabilo, WA2EZN, (201) 767-3575.

NORTH CAROLINA: The Raleigh Amateur Radio Society's 10th annual Hamfest, April 18, 8 AM, Crabtree Valley Mall, US 70 West, Raleigh. First prize: Kenwood TS830S HF transceiver OR Icom IC251A 2m transceiver; second prize: Icom 25A 2m transceiver and many more prizes. Expanded covered flea market, special interest meetings, nearby motels and restaurants. Talk in W4DW 146.04/146.64; K4ITL 146.28/146.88. For information/reservations: RARS Hamfest, P.O. Box 17124, Raleigh, NC 27619.

OHIO: The Toledo Mobile Radio Association's 27th annual Auction and Hamfest, Sunday, March 21, Lucas County Recreation Center, Key Street, Maumee. 8 AM to 5 PM. Auction starts at 10 AM. Tickets $2.00 advance; $3.00 door. Flea market tables available, electronics and ham gear only. Refreshments, door prizes and big raffle. Prizes include Kenwood TS-130S w/power supply; Kenwood TS-2500 Handy Talkie, Icom IC-2AT Handie Talkie and much more. Special ladies' programs. Area repeaters are 146.01/61, 19/79, 34/94, 147.87/27 and 975/375. Talk in on 146.52/52. For more info: J. Honisko, KB8YD, 1733 Parkway Drive N., Maumee, Ohio 43537.

OHIO: The 4th annual Lake County Hamfest, Sunday, March 28, 8 AM to 4 PM, Madison High School, Madison. Admission: $2.50 advance; $3.50 gate. Food, prizes. Main prizes: Kenwood TR9000 2m transceiver; Kenwood TR2500 HH 2m transceiver; Mirage B108 2m amplifier. Hourly door-prize drawings. Talk in on 147.81/21. For details call: (216) 953-9784 or write: Lake County Hamfest Committee, 5704 Middle Ridge, Madison, Ohio 44057.

PENNSYLVANIA: The Conemaugh Valley Amateur Radio Club's fifth annual Hamfest, March 28, Sandy Bottom Sportsman's Club, Seward, ten miles NW of Johnstown. 8 AM to 4 PM. Refreshments available. Good prizes. Check in on 146.34/94 repeater. For information: Conemaugh Valley ARC, 2829 Bedford Street, Johnstown, PA 15904.

PENNSYLVANIA: The Eight annual Northwestern Pennsylvania Hamfest, May 1, Crawford County Fairgrounds, Meadville. Gates open 8 AM. Bring your own tables. $5 per table to display inside, $2 per car space outside. $3 admission, children under 12 free. Refreshments. Commercial displays welcome. Talk in 04/64, 81/21, 63/03. Details: C.A.R.S., P.O. Box 653, Meadville, PA 16335. Attn: Hamfest Committee.

PENNSYLVANIA: Tradefest '82 sponsored by the Penn Wireless Association, Sunday, March 7, National Guard Armory, Southampton Road and Roosevelt Blvd., Langhorne. General admission $3. Bring own tables; power connections $3.00. Prizes, refreshments, rest areas, displays and surprises. Talk-in on 146.115/715 and .52. Contact: Mark J. Pierson, KB3NE, P.O. Box 734, Langhorne, PA 19047.

NEW JERSEY: Annual Flemington Hamfest Saturday, April 3 from 8:30 to 3:30 at the Hunterdon Central High School Field House. 20,000 square feet of heated indoor area. Gigantic flea market, 200 tables, major manufacturers, and more. Bring the XYL, kids and friends. Flemington is located between NYC and Philadelphia at the intersection of routes 202 and 31 just 10 miles south of I-78, and is a tourist area. Talk-in 146.52, 147.375, 147.015, 224.12 and 224.54 MHz. Admission $3.00 donation. For reservations or information call 201-788-4080 or write Cherryville Repeater Association c/o W2FCW, Box 76, Farview Dr., Annandale, NJ 08801.

KNOXVILLE, TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day weekend, May 22-23. DX, computer and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

WEST VIRGINIA: Attention Dealers! Wheeling WV Hamfest, July 25. White Palace, Wheeling Park. Attendance from 3 states, 1000 car parking. Reserve space. Contact: TSRAC, Box 240, RD 2, Adena, OH 43901.

WISCONSIN: The Madison Area Repeater Association's tenth annual Swapfest, Sunday, April 4, Dane County Exposition Center Forum Building, Madison. Doors open 8 AM for sellers; 9 AM for public. Admission $2.50 advance, $3.00 door. Tables $4.00 ea. advance/$5.00 ea. door. Door prizes; all-you-can-eat pancake breakfast and Bar-B-Q lunch available. Talk in on WR9ABT, 146.16/.76. For reservations/information: M.A.R.A., P. O. Box 3403, Madison, WI 53704 or Clyde Downing, W9HSY, P.O. Box 3403, Madison, WI 53704. (608) 222-1035.

NEW HAMPSHIRE: The Interstate Repeater Society's annual Hamfest and Flea Market, Saturday, March 13, Merrimack Hilton Hotel, Merrimack. 9 AM to 4 PM. Tables available at $10.00. Admission: $1.00. Prizes during day. Dinner dance with live music and entertainment. Talk-in on 146.25/85 and 146.52. Further information: Ken Soares, N1BAD, P.O. Box 94, Nashua, NH 03061 or on 25/85.

OPERATING EVENTS

"Things to do..."

MARCH 20: YL ISSB QSO Party. 0001 GMT, March 20 to 2359 GMT, March 21 (CW). 0001 GMT, April 24 to 2359 GMT, April 25 (Phone). Send logs, summary sheets, complete YLISSB QSO Party applications to: K0ROJ or KA0ALX.

MARCH 21: Wisconsin QSO Party. 1800 Z, March 21 to 0200 Z, March 22. (8 hours) CW and phone. Frequencies: CW: 3570, 7070, 14070 kHz. Phone: 3990, 7290, 14290 kHz. Logs, prior to May 1, to: Wisconsin QSO Party, c/o West Allis Radio Amateur Club, P.O. Box 1072, Milwaukee, WI 53201.

MARCH 28: A Special Event Station, W3FT, commemorating the annual Baltimore Amateur Radio Club's 1982 Hamboree and Computerfest. This station will be operated by the members of the Catonsville Community College ARS from the Maryland State Fairgrounds, Timonium, from 1200 to 2100 UTC. Frequencies: Phone — 7.275, 14.290, 21.365, 28.550 ± QRM. CW — 7.110, 21.120, 28.120 ± QRM. A certificate will be issued to Amateurs contacting W3FT upon receipt of QSL card and 40¢ U.S. postage. Foreign remit 2 IRCs. QSL via KA3GSN or KA3ENU, '82 Callbook.

MARCH 13. The 1982 Virginia State QSO Party sponsored by the Sterling Park Amateur Radio Club. 1800Z, Saturday, March 13 until 0200Z, Monday, March 15. 3 categories: Fixed/portable, single transmitter; fixed/portable, multitransmitter and mobile. Exchange QSO number, QTH (county for VA stations, state, province or country for others.) Suggested frequencies: Phone — 3930, 7230, 21375, 28575. CW: 60 kHz from low end and Novice bands. Plaque to high VA score and certificates to other high scores. Mail logs no later than April 15, 1982, to: A. Ray Massie, K3RZR, Rt. 1, Box 115E, Dunnsville, VA 22454. SASE for results.

MARCH 27: Ramapo Mountain Amateur Radio Club's UHF/VHF QSO Party. 1600 Hrs (local) Saturday, March 27 to 2400 Hrs (local) Sunday, March 28. 1982 contest rules considerably different from previous two contests. For log/entry forms SASE: RMARC, P.O. Box 364, Oakland, NJ 07436.

APRIL 7: DX YL to North American YL. All licensed women operators throughout the world invited to participate. CW starts Wednesday, April 7, 1800 UTC; ends Thursday, April 8, 1800 UTC. Phone starts Wednesday, April 14, 1800 UTC; ends Thursday, April 15, 1800 UTC. DX YLs call "CQ North American YL". N.A. YLs call "CQ DX YL". All bands may be used. No cross band operation. Nets, repeaters, OM contacts do not count. Please send logs prior to April 29, 1982, to: YLRL Vice President Sandra Heyn, WA6WZN, 962 Cheyenne Street, Costa Mesa, CA 92626.

APRIL 17: QRP AMATEUR RADIO CLUB International SSB QSO Party. 1200 UTC Saturday, April 17 to 2400 UTC Sunday, April 18. Operate max. 24 hours. Call CQ QRP. Suggested frequencies: 1810, 3985, 7285, 14285, 21385, 28885 and/or 50385 kHz ± interference clearance. VHF/UHF direct — no repeaters. Send logs and scoring to: QRP ARCI Contest Chairman, William Dickerson, WA2JOC, 352 Crampton Drive, Monroe, MI 48161.

APRIL 1982 / $2.50

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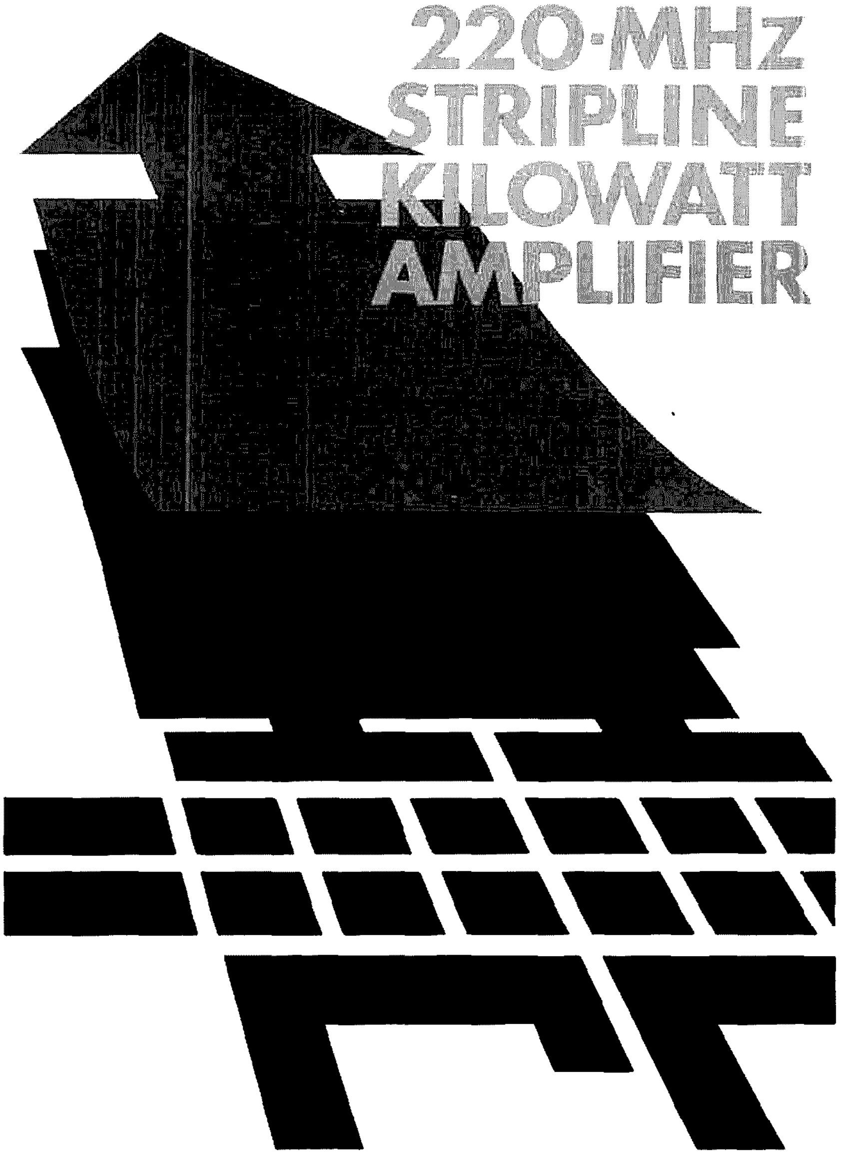

focus on communications technology

ham radio

magazine

APRIL 1982

volume 15, number 4

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contents

Observation & Opinion

During my ham career, I have always been an enthusiastic member of the DX fraternity. I've been through more sunspot cycles than I care to remember, always trying to increase my DXCC country total, and I have managed to accumulate a fairly respectable number of confirmed contacts. All this took place when I was in California. There I had all the trappings considered necessary to compete with the big guns in kilowatt alley and was able to hold my own pretty well in the pile-ups. However, things have changed — and for the better, I might add.

My move from California to New Hampshire required that I put all my ham gear, some 35 years' accumulation, in storage, where it still remains. But strangely enough, I don't really miss it. I've rediscovered a new and far more challenging pursuit, one that I followed only casually in California — the world of QRP, or low-power operation.

With the kind help of Skip Tenney, I was on the air with borrowed equipment and a longwire antenna shortly after I arrived in New Hampshire. The gear was nothing exotic — just a good high-frequency transceiver with adjustable power output and a few accessories. My experience with this borrowed rig, operating from a good location (for a change), has been most rewarding. It's altogether a different game chasing DX stations when you don't have a big antenna and a kilowatt amplifier.

The term QRP is from the international list of Q-code signals and means *reduce power*. QRP operation in the Amateur bands has several definitions, depending on whom you talk to. To some, anything below 100 watts is QRP. However, true QRP is generally recognized as an input power of 10 watts or less, and 1 watt or less is called QRPp. With a good antenna and only a few milliwatts, tremendous distances can be covered in the high-frequency bands. But this kind of achievement is possible only with skillful operating and, above all, patience and perseverance.

A certain etiquette and some unwritten rules prevail among the QRP brethren. These have evolved over the years and are generally accepted by serious operators. For example, it's not considered good form to make contact with high power then ask the station to listen for your QRP signals. Another practice frowned upon is making prior arrangements with a station for a QRP contact. It is also considered unethical to have a friend ask the desired station to "stand by for W6BLANK using QRP." I tried a few of these tactics during my early days of QRP operating before I learned how to behave. True, I made some contacts, but they didn't seem as rewarding as those made according to the rules.

I've heard some operators say that it isn't very productive for a QRP station to call CQ. This may be true during the early evening hours when the bands are crowded; however, I've found that if I get on the air late at night, find a clear spot, and call "QRP" several times followed by my callsign, it is possible to obtain replies. Furthermore, many foreign stations enjoy working U.S. QRP stations, as I have discovered on 40 meters, especially near 7025 and 7060 kHz. Overseas operators also do a lot of listening, and I was surprised one evening to find that stations were actually calling me after I finished a QSO with a Belgian station. What an experience! I'd actually created a mini pile-up.

It doesn't take much equipment to get a QRP station on the air. A simple but stable VFO will serve as a transmitter. A selective receiver is important, and the antenna should be as efficient as you can possibly make it. Although a gain antenna is an asset, a simple, well-matched dipole will give good results in QRP work.

If you want to experience a real sense of achievement resulting from some rigid operating discipline, I highly recommend QRP work. Now, I wonder who will be the first U.S. ham to earn the Worked All Continents award with 500 milliwatts on the new WARC bands?

Alf Wilson, W6NIF
editor

comments

Pendergast's return

Dear HR:

The article on traps in the October issue is excellent stuff. Very seldom do I get so interested in the first article that I get stuck there to the temporary exclusion of the rest of the magazine. I normally scan the whole issue first and start with the one that interests me most. The return of the magazine to an emphasis on technical excellence is most encouraging. Congratulations on a good job.

A couple of small points. In the July issue, page 52, 0.707 of the power has somehow become half the power; 0.707 of the field strength *in volts* would be half the power.

In the August issue I couldn't help a feeling of foreboding that Pendergast had snuck back into Bill Orr's material, and sure enough when I arrived at work there was a note from a colleague saying, "If you are writing to *ham radio* for Pete's sake complain about Pendergast's return." I am hereby passing on that message, with a fervent plea from me that Pendergast stay dead. Bill Orr is often interesting, but the dialogue sometimes gets in the way. I know many readers that feel this way, and can honestly say that I don't know anyone who likes Pendergast. It was most encouraging to see no mention of **P.** in October!

To come back to the Gary O'Neil piece on traps, I think it would interest all readers if you could print a note from Gary on the kind of power his RG8/U traps can handle, and how far off frequency you can operate before the trap heats up because of circulating current. And here is a question. When feeding a trap dipole directly with coax (no balun), I find the trap in the side connected to the braid gets hot enough to melt the encapsulant, while the other one stays cool. Why? (Swapping them confirms that it is the position, not the trap, which causes the heating.)

Bob Eldridge, VE7BS
Pemberton, B. C.

lifeline SAR

Dear HR:

We are a volunteer, non-profit public service organization headquartered in Madison, Indiana, and we're looking for members from all over the world. Our prime objective is to form local chapter units for those areas that don't already have a qualified search and rescue (SAR) organization. There are, unfortunately, all too many such areas.

Our organization currently possesses members in 27 divisions (25 states plus Canada and the Republic of Singapore). We rely on Amateur Radio as a back-up communications network and for any long-range traffic we may have. Our primary means of communications is our own VHF-fm commercial radio system.

In addition to looking for members, we are also looking for donations of radio equipment (both VHF-fm commercial and Amateur) to help us build our organization and its chapters up to an operational level. All donations (cash and otherwise) are 100 percent deductible for federal income tax purposes.

Everyone is eligible to apply for membership. Those who inquire are asked to enclose an SASE to help with the rising costs of mailing. All inquiries will be answered promptly. For further information, please write Lifeline Search and Rescue, P.O. Box 237, Milton, Kentucky 40045.

Jeff E. Howell, CEMT (WB9PFZ)
Executive Director
Lifeline SAR

a card from Frenchy

Dear HR:

Bill Orr's article in the August issue brought back fond memories of DX for a then-young Amateur. After I got my ticket in mid 1938, it took me almost a year to scrounge up the parts for my homemade superhet and 6A6-PP6L6 transmitter.

By that time World War II had drawn the curtain over much of the DX, but nevertheless, my spare and weekend hours were spent listening for something "rare."

One early morning in December of 1939, there was the same KF6ROV mentioned in Bill's article, calling CO; with trembling hand I called him, and "Frenchy" Paquette in Pago Pago came back to my call. This is one of my most prized QSLs.

Thanks again to Bill and to you for a fine magazine.

F.V. Sprick, W2LPV
Clifton, New Jersey

kilo foxtrot Charlie?

Dear HR:

In regard to the comments by Mr. H.B. Mouatt, W6BQD, in the January, 1982, issue, I am in full agreement. The use of Q signals on phone has long been a source of improper operation, insofar as they are intended for use on CW. If one is going to stop transmitting, simply say so, not QRT. I am sure there are others, but this is one I hear a lot. This practice seems to be common among newcomers and old-timers as well.

The use of one's own phonetics for one's own call, however, seems to be perfectly proper to me. I have heard both U.S. and foreign Amateurs use their own personal phonetics many times. In fact, one very good friend, Vic Clark, W4KFC (past ARRL VP and Roanoke Division Director), would probably be unrecognizable to me on the air if he were to say Whiskey Four Kilo Foxtrot Charlie instead of W4 Kentucky Fried Chicken.

Ed Redington, Jr., N4AGS
Ashland, Virginia

presstop

THE FCC HAS ACTED IN THE JAMMING cases involving the Maritime Mobile Services Net. In a release dated January 28, 1982, the Commission revoked the license of Leonard M. Boucher, K4MME, of Cantonment, Florida, and at the same time suspended for one year the license of Gerard Morin, W1GM, of Sanford, Maine. In their "Order of Revocation and Suspension" the Commission found that, between August, 1980, and June, 1981, Boucher and Morin operated in a split frequency scheme designed to deliberately and maliciously interfere with radio nets operating on the frequency of 14.313 MHz.
Boucher Received The Greatest Amount Of Attention and criticism from the FCC. They noted that on February 17, 1981, they monitored Boucher requesting a station to move down with him to the frequency on which net participants were operating, and on February 18th he was again heard to criticize the operator of a station for not moving directly on top of the frequency occupied by the net. Other instances were cited as well.

A5 MAGAZINE HAS PROPOSED SSTV operating frequencies based on the recent approval of FCC Docket 80-252 which expands SSTV/FAX operations in the General Class phone bands. A5 proposes the following frequencies: 3.990, 7.290, 14.340, and 21.440 MHz with all movement upward only utilizing the top 10 kHz of band edges. Any comments should go to Mike Stone, WBØQCD, A5 Magazine, P.O. Box H, Lowden, Iowa 52255. Mike will also be on hand at the 1982 Dayton Hamvention's ATV Forum at 2:00 PM on Saturday, April 24th.

ARNIE VERDOW, WØLIJ, a familiar sight at many hamfests as he manned the Collins booth, passed away February 1. His easy going, likable manner, along with his extensive first-hand knowledge of post-war Collins products, combined to make him a favorite in the Amateur community. He will be missed as a professional but even more as a good friend.

THE UNITED STATES WILL SOON HAVE A "WOODPECKER" operating in the 5 to 35 MHz spectrum. Like its Russian counterpart, it also will be an over-the-horizon radar system. It will be located near the city of Moscow, Maine. Built by General Electric Corporation under contract to the U.S. Air Force, it will have an ERP of 1.2 megawatts. The system is in its final testing stage, with full-time operation scheduled to begin sometime in 1982. What effect our woodpecker will have on Amateur Radio hf communications is unknown, but the military has promised to work with the Amateur community to reduce its impact.

DR. NORM CHALFIN, K6PGX, REPORTS that Wednesdays (UTC) are Experimental Days on the Soviet R/S Satellites. During that time, the birds are reserved for previously arranged uplink transmissions. Chalfin also informs us that all passbands on the R/S transponders are linear; that is, USB in on 2 meters produces USB out on 10.

SATELLITE TELECASTERS ARE GOING TO GREAT LENGTHS to try to end the pirating of their subscription services. Premier Communications Network of San Jose, California, placed an advertisement in a recent edition of the San Jose Mercury newspaper appealing to area residents to trade in their "illegal" pirate antennas on a "legal" installation from their company for Home Box Office service. The newspaper ad contains a reprint of findings regarding the secrecy of communications provisions of Section 605 of the Communications Act, and it then offers amnesty along with guaranteed service to anyone answering the ad and becoming a subscriber.
Swift Reaction Has Come From The Area's Local Amateurs. Writing in the Bay Area 220 Group newsletter, Pres. Jerry Lahtinen, W6TTU, stated that his organization considers HBO to be the real pirates since that service utilizes publicly owned spectrum, and he has called for the abolition of HBO entirely.

AN ON-SITE ALERT AT THE R.E. GINNA NUCLEAR PLANT January 25th saw hams from Rochester, Monroe County, and Wayne County (New York) put themselves on alert as well. Fortunately, the problem did not require evacuation of the area and the alert was downgraded just a few hours later. Ironically, this "real alert" followed only four days after a mock Nuclear Evacuation Drill had been held in the same area.

RE-BALLOTING IN TWO DISPUTED ARRL DIRECTOR'S ELECTIONS show that the incumbents, William Stevens, W6ZM, (Pacific Division), and Leonard Nathanson, W8RC, (Great Lakes Division), have been re-elected. According to League headquarters, in each case the winner's margin was almost 2:1 over his opponent.

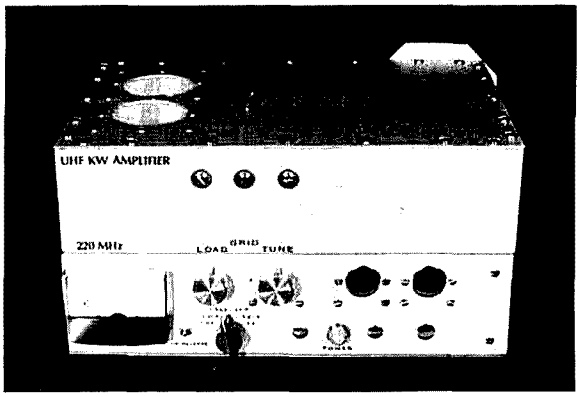
ON JANUARY 4TH THE FCC BEGAN ISSUING the new General Radiotelephone license to replace the 1st and 2nd class phone licenses that were discontinued last year. The order initiating the change came last August but could not be implemented until new license forms had been printed. Current holders of 1st or 2nd class tickets should note that they are valid until expiration, but when renewed they will become General Radiotelephone licenses. All new licenses will be of that class as well.

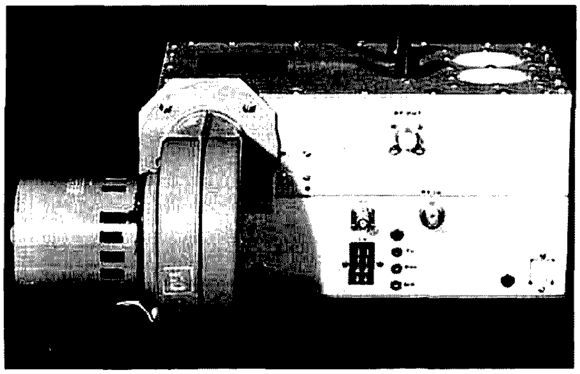
stripline kilowatt amplifier
for 220 MHz

Updated version of a design published previously in *ham radio*

The **144-MHz stripline kilowatt** amplifier described in the October, 1977, issue of *ham radio*[1] has been constructed and operated by a number of Amateurs, both from the information in the article and from parts kits available from ARCOS.* A 220-MHz version of this amplifier was built and tested during 1977 and has been reproduced several times. One of these models has been in service on a 220-MHz repeater for over two years. This same amplifier was borrowed from the repeater and used during VHF/UHF tests over the past two years by the W2SZ/1 (Mount

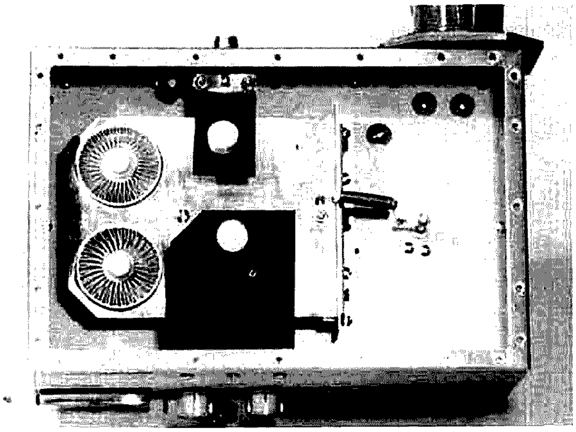
*ARCOS, Amateur Radio Component Service, Box 546, East Greenbush, New York 12061. All parts for the 220 amplifier and power supply are available.



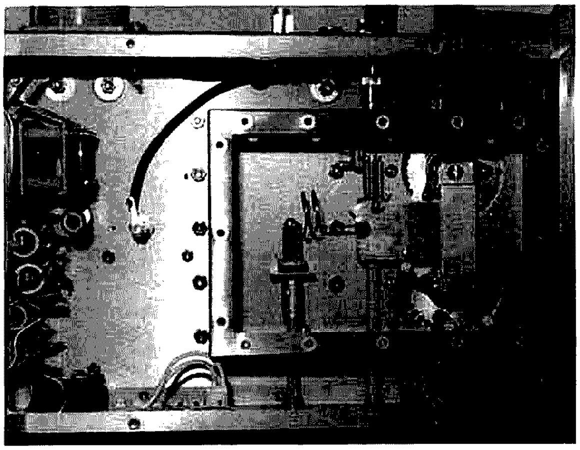


Front and rear views of the 220-MHz stripline kilowatt amplifier, which is enclosed in two mated chassis. Two optional designs are available, one for triode and one for tetrode tubes.

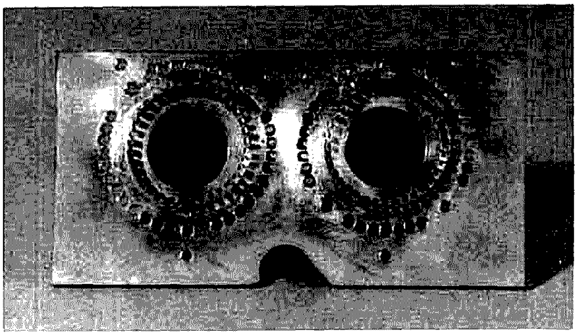
By **F. J. Merry, W2GN,** 35 Highland Drive, East Greenbush, New York 12061



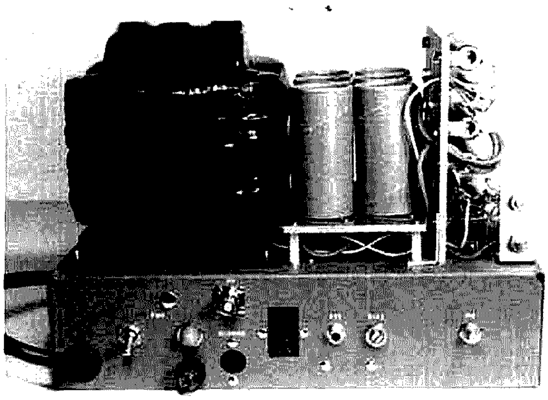
Top view of the stripline amplifier with cover removed showing the load and tuning flappers.



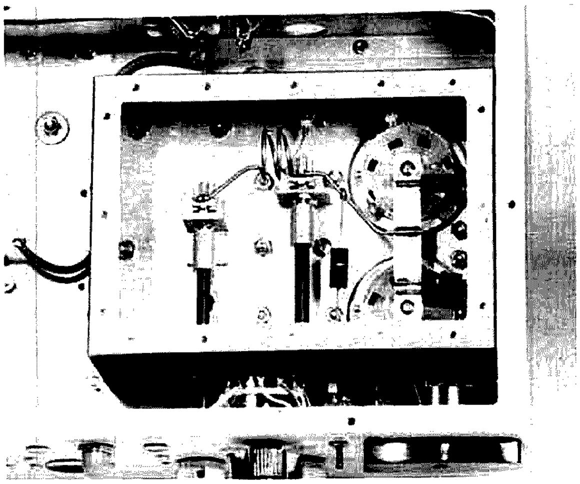
Bottom view of the triode amplifier with cover removed.



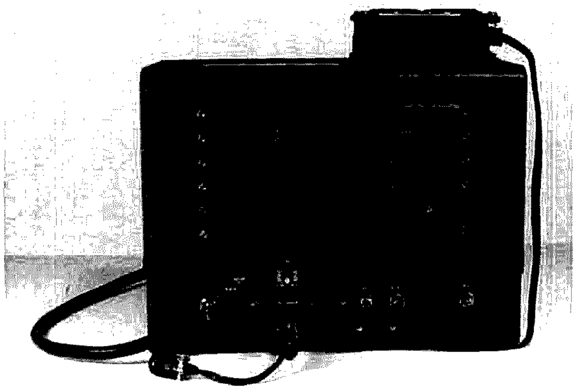
Socket assembly for the 8874 triodes, which may be installed onto the amplifier chassis in place of the tetrode sockets.



Front view of the power supply with cover removed.



Bottom view of the tetrode amplifier with cover removed.



Front view of the power supply for the stripline amplifier with cover installed.

Greylock) group. Experience has been favorable in all respects.

The experienced builder, especially if he has *built* the 144-MHz model, will find no difficulty in building and operating the 220-MHz version. With EME and tropo activity on 220 MHz on the increase, this amplifier is a good candidate where there is a need for reliable high-power operation.

Similar to the 144-MHz amplifier in chassis dimensions and other respects, the 220-MHz version uses a quarter-wave plate line and a coil-simulated half-wave grid line. Except for the plate-line mounting screws, the location of the high-voltage feedthrough capacitor and a hole for a bushing for the plate tuning flapper drive string, chassis punching is identical to the drawings for the 144-MHz amplifier as described in reference 1. Originally described by K2RIW (reference 2) for a 432-MHz stripline amplifier, this type of chassis construction has proven adaptable to not only 432, 220, and 144 MHz but also to an equally successful 50-MHz version using a pi-network output circuit with inductive tuning. The 50-MHz model will be described in a subsequent article.

The amplifiers mentioned above can use any of the ceramic tetrodes such as the 4CX250R, 4CX250B, or 8930, further illustrating the flexibility of this type of chassis construction. The 8874 triodes can also be used in a grounded-grid application by installing a mounting plate for the 8874 sockets in place of the individual EIMAC 630A sockets. The triode amplifiers have the advantage of not requiring the critical screen supply voltage and the disadvantages of higher tube cost and higher drive power requirement.

design

Referring to the schematic, (**fig. 1**), the quarter-wave plate line is tuned and loaded by flapper capacitors. The plate blocking capacitor is a Teflon sandwich at the cold (rf) end of the line. The grids are connected by a strap to which is connected the grid coil. A 1k, 2-watt resistor is used for a grid choke (class AB1 operation — no grid current). A 1k, 2-watt resistor in series with a 1000-pF capacitor is connected to ground from each grid. These two loading resistors increase the stability margin of the amplifier and desensitize it so that it can be driven to 500 watts output with about 10 watts of drive. Additional resistors may be added depending on the drive power available. If the grid load resistors are omitted, the amplifier is stable but it becomes extremely power sensitive.

A further examination of the schematic reveals an optional rf output indicator circuit and 660-MHz and

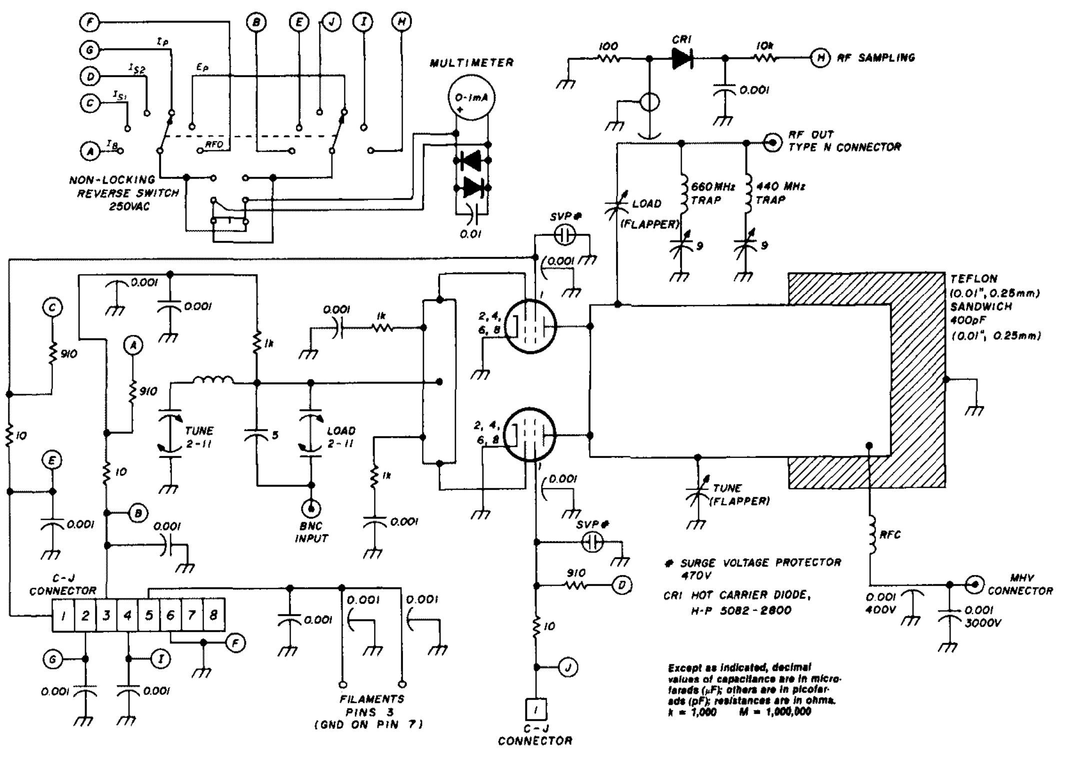


fig. 1. Schematic diagram of the tetrode stripline kilowatt amplifier.

440-MHz harmonic traps in the rf output, surge voltage protectors (SVPs) on the screen leads, and the usual lead filtering to keep the rf locked into the grid box and plate compartment. Metering is with a single 0-1 mA meter and a six-position switch with appropriate metering resistors for plate current, plate voltage, individual screen currents, grid current, and relative rf output. Thus, all important operating parameters are monitored.

A nonlocking reversing switch facilitates reading negative values of screen and grid currents, which are normally experienced with tetrode amplifiers. I recommend that an rf output wattmeter be used instead of the relative rf output indicator circuit. Proper adjustment of the plate tuning controls is difficult unless both plate current and the rf power output can be observed simultaneously. Other dc metering arrangements may, of course, be employed, including enclosing the meter circuit in a separate box at the operating position with the amplifier remotely located or by locating the metering circuit in the power-supply chassis.

The surge-voltage protectors in the screen circuit will ground the screens if the screen voltage rises above 470 volts. This protection is important and should be provided on all tetrode amplifiers. Emission effects in ceramic tetrodes will cause the screen to go negative under certain operating conditions. When this condition occurs, the screen voltage rises, causing higher plate current. The tubes can go into a runaway condition unless the amplifier is shut down. The surge voltage protectors prevent the runaway condition by automatically reducing the screen voltage to a very low value. Once one of the SVPs has fired, it's usually necessary to shut off the power. Power may be restored after a pause to let the capacitors discharge to a point below the sustaining voltage of the SVP that fired. A small saving can be realized by using only one SVP connected to the screen-supply lead.

Two other factors are involved in foolproof operation of the screen circuit:

1. The screen power supply must be provided with a current-limiting resistor so that the current doesn't exceed about 100 mA when one of the SVPs fires.

2. The power supply must have a resistor, from screens to negative, which is of a value low enough to provide a sink current of at least 40 mA. This feature provides a path for the negative screen current so that the screen voltage will hold at the regulated value.

With the above features provided in the screen circuit, the tetrode amplifier will perform as reliably and smoothly as a triode amplifier.

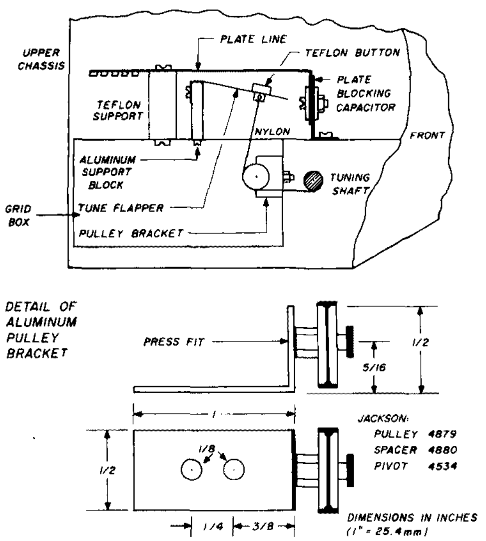


fig. 2. Cross-sectional diagram illustrating operation of plate-tuning flapper. The diagram is for front-panel control. Alternatively, the plate-tuning flapper may be located above the plate line and adjusted with a screw and knob (like the load flapper).

construction*

Chassis punching and drilling follows the same pattern shown by the drawings and as discussed in the 2-meter amplifier article.[1] Variations are listed below.

Plate-line mounting holes. The five holes in the right end (facing front) of the upper chassis (used to mount the 2-meter plate line) are not required. The 3/16 inch (5 mm) holes that fasten the 1-1/4 meter plate line to the chassis are located by setting the line in place with the tubes installed.

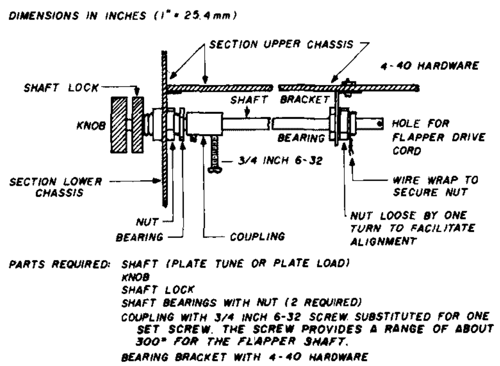


fig. 3. Sketch illustrating assembly of flapper control shaft with shaft lock. This assembly is used in place of planetary drives. It provides a greater range of adjustment and more positive operation.

*See the appendix before proceeding further.

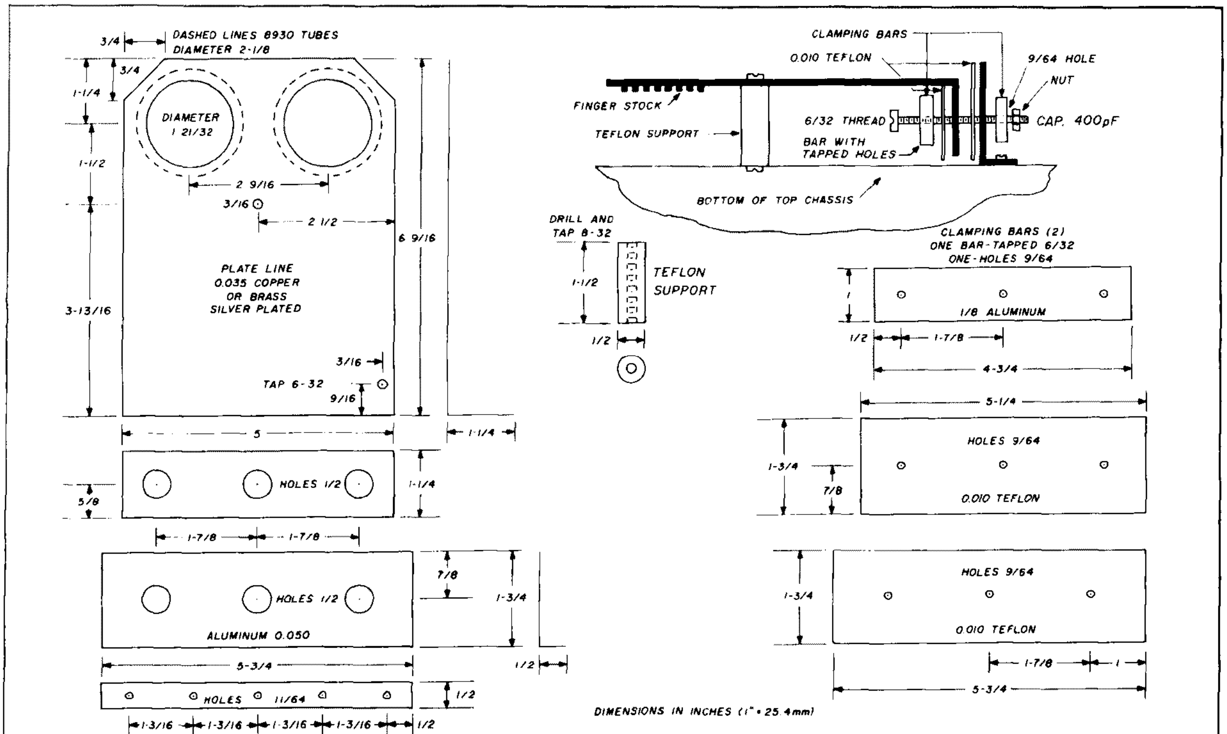


fig 4. Plate-line details of the 220-MHz stripline kilowatt.

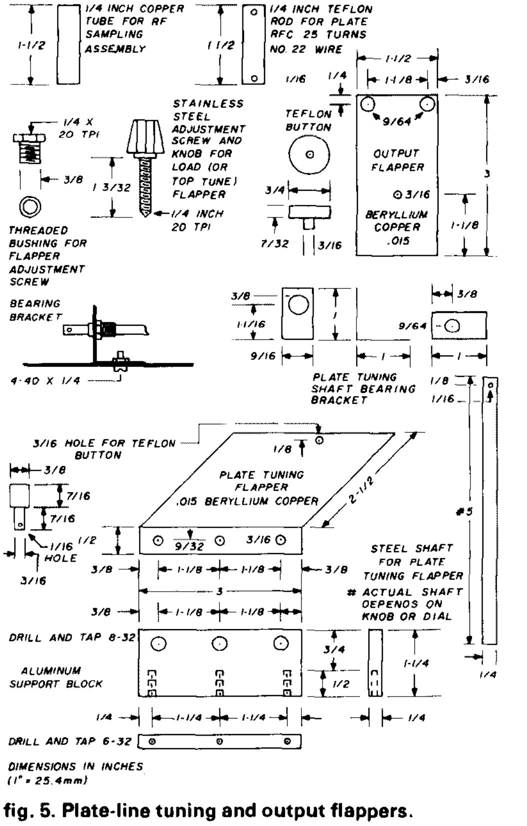


fig. 5. Plate-line tuning and output flappers.

Mounting the high-voltage feedthrough capacitor. The 7/16 inch (11 mm) hole for the high-voltage feedthrough capacitors is located 2 inches (5 cm) to the right (facing the front of the amplifier) of the cold end of the plate line and in line with the rear edge of the plate line. The rf choke is mounted between a lug on the plate line and another lug on the high-voltage feedthrough capacitor.

Plate-tuning flapper. The plate-tuning flapper is mounted on an aluminum block as in the 2-meter amplifier. It is shorter than the 2-meter flapper. The drive cord is connected to the tuning control through a pulley inside the grid box, **fig. 2.** A knob shaft lock and a steel shaft provide the plate tuning adjustment, **fig. 3.**

An alternative method of installing and controlling the plate tuning flapper is to secure it to the front of the upper chassis wall and adjust it with a 1/4 inch (6.4 mm) threaded rod from the top of the chassis — a simple and positive method of control, the same as that used to control the plate load flapper.

Plate line. The construction of the plate line is shown in **figs. 4** and **5.** The parts of the line must be free of burrs to avoid puncturing the Teflon insula-

tion. Assembly of the line must be accurate so that the screws holding the clamping bars are centered in the holes in the plate line and the underside of the plate line is 1-1/2 inches (38 mm) from the floor of the upper chassis.

Grid circuit. Details of the grid circuit are shown in **fig. 6**. Miniature capacitors (20-pF) may be substituted for the butterfly caps. The advantage of the costly butterfly cap is that no bearings are included in the rf path. The 2-11 pF butterfly caps will require a10-pF padder mounted across the two stators.

triode amplifier

If the 8874 triodes are the tube choice, the sockets can be mounted on a brass plate, which is then installed onto the amplifier chassis in place of the EIMAC 630A sockets used for the tetrodes, **fig. 7**. There's no need to change dimensions of the plate line provided it's for the 4CX250 tubes. The grid line becomes the cathode line, and an rf choke is substituted for the 1k, 2-watt grid resistor. The grid load resistors are also omitted. See the schematic of the triode version, **fig. 8**.

Note that the triode amplifier has two meters mounted on the chassis. The right-hand meter reads plate current; the left-hand meter reads grid current. By operating a nonlocking meter switch, plate voltage is read on the grid-current meter. (I assume that an rf wattmeter will be used to monitor power output.)

Metering and cathode resistors are mounted on the right-hand end of the lower chassis. The zener bias diode and the control connector are mounted on the rear of the lower chassis. An ungrounded contact closure on the control connector is required to establish operating bias.

harmonic traps and rf indicator pickup

The harmonic traps (440 MHz and 660 MHz) in the rf output are installed in a small box (Pomona 2428) mounted on the rear of the amplifier, **fig. 9**. Alternatively, these traps can be installed in a box with coaxial connectors on each end (Pomona 2411). This box can be inserted in the output line at the rf output connector or immediately following the output wattmeter. The adjustment of these traps is best done

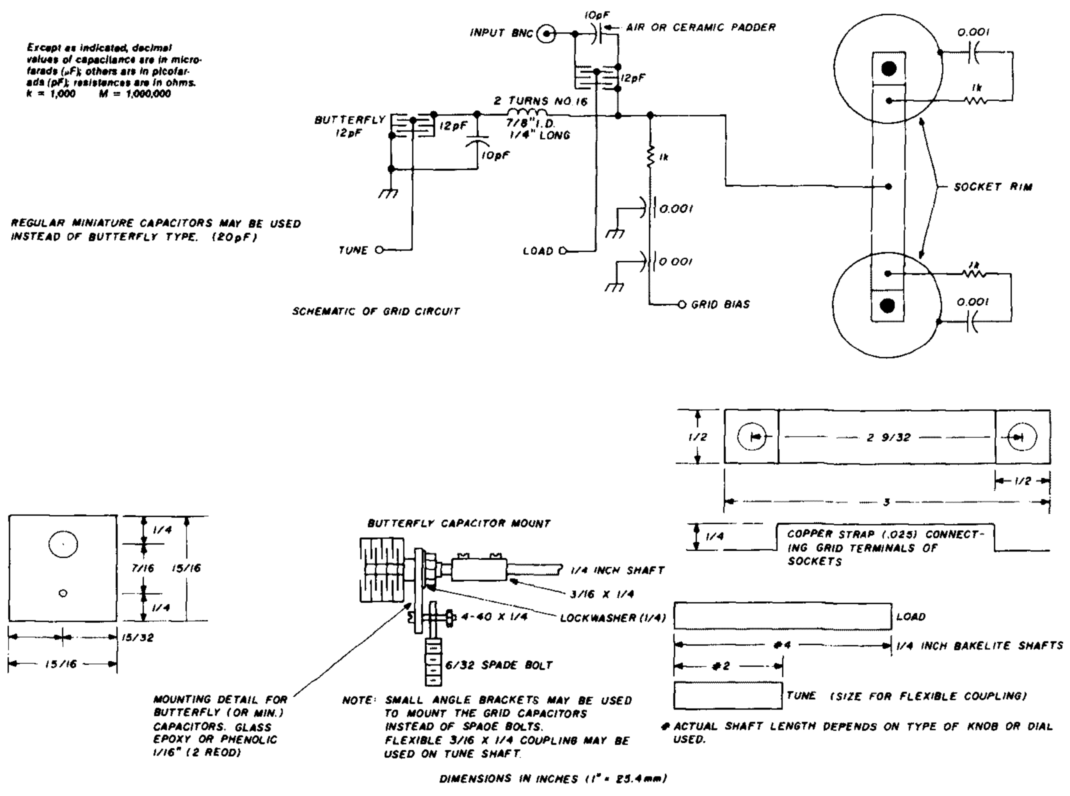


fig. 6. Grid-circuit details. The butterfly caps will require a 10-pF padder mounted across the two stators.

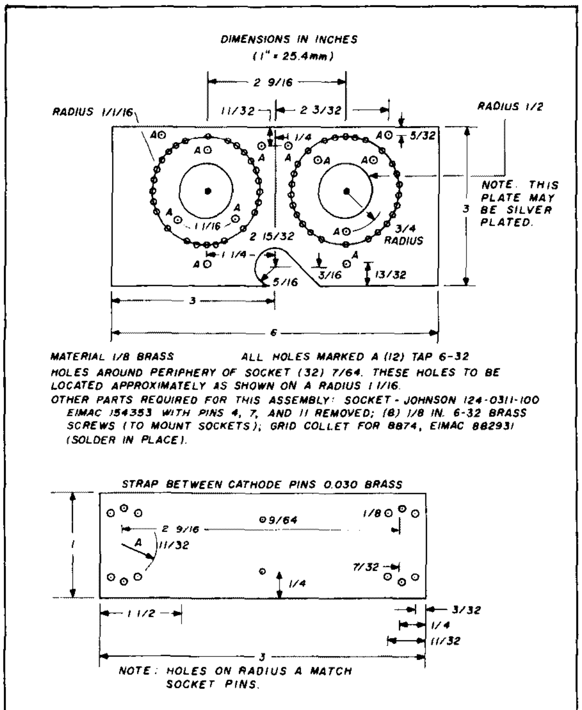


fig. 7. Socket plate for the 8874 amplifier.

while observing the level of the harmonic output on a spectrum analyzer.

The rf pickup assembly is also illustrated in **fig. 9.** The amount of rf pickup is obtained by adjusting the position of the lug, which is mounted on top of the output flapper, with respect to the lug on the standoff insulator.

The rf pickup assembly may be omitted if you plan to have an rf wattmeter in the output circuit. As I mentioned previously, it's desirable to have an rf wattmeter to monitor output and to achieve the best adjustment of plate tune and load controls for maximum efficiency.

assembly

The following sequence is suggested for assembly:

1. Mount and wire all parts on the lower chassis.

2. Fasten the grid box to the upper chassis and install the sockets, feedthrough capacitors, SVPs and BNC input connector. For the tetrode amplifier, orient the sockets so that terminals 1 and 3 are opposite their respective feedthrough caps. The sockets for the triode amplifier are mounted so that the heater terminals are positioned between their respective feedthrough capacitors on the cathode box.

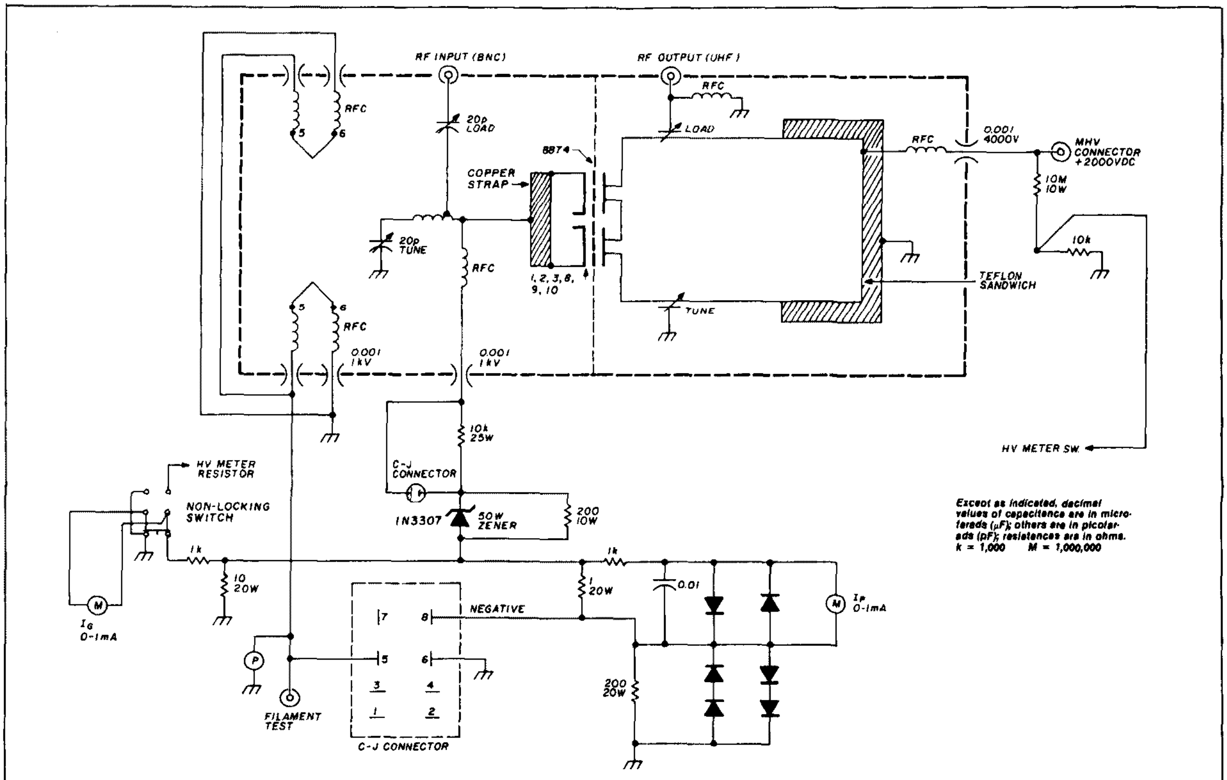


fig. 8. Schematic diagram of rf section, triode amplifier.

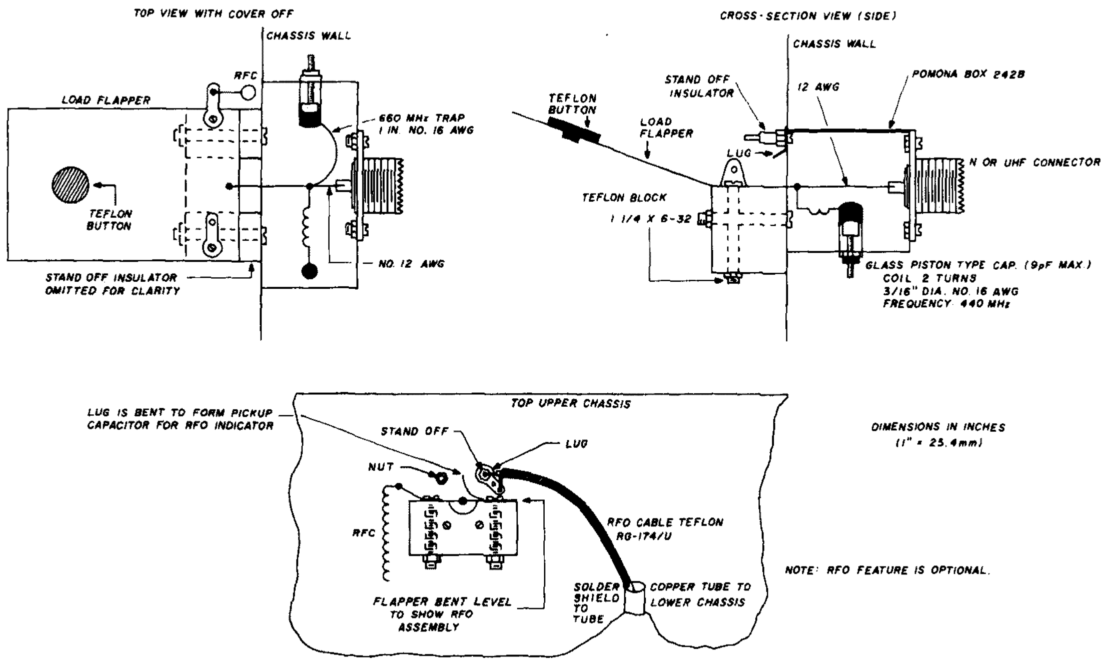


fig. 9. Harmonic traps and rf indicator pickup assembly.

3. Install the high-voltage feedthrough capacitor and the rf output pickup assembly.

4. Fasten the upper and lower chassis together and complete the wiring interconnections.

5. Mount the butterfly caps in the grid box (**fig. 6**) and install the tune and load controls.

6. Install the grid line, grid coil and resistors as in **fig. 6**.

7. Install the plate-tuning flapper, pulley, dial, shaft and bearing. Tie the nylon line to the flapper before mounting the flapper.

8. Install the tubes temporarily and put the plate line (previously assembled) in place. Work the finger stock over the tubes *very carefully*. Make sure everything lines up. Mark the mounting holes at the end of the plate line, then remove the plate line and tubes and drill the mounting holes for the plate line. Reinstall tubes and plate line.

9. Connect the plate rf choke.

10. Install the output flapper, rf grounding choke and RFO assembly.

11. Assemble the top plate screen and vent plate and the threaded bushing for flapper adjustment. Put the tubes in place and put the Teflon chimneys in position in the vent plate. Fasten the top plate in place.

12. Recheck wiring and fasten the bottom plate.

The amplifier is now ready for test.

blower

The blower may be mounted onto the air-intake plate on the rear of the amplifier or it may be hose connected. The Dayton model 4C012A specified in the 2-meter construction article[2] is satisfactory for normal operation. **Figs. 10** and **11** give the dimensions for air-intake plates for higher-power blowers;

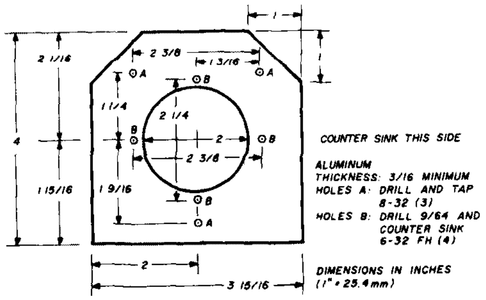


fig. 10. Air intake cover-plate details, Dayton 4C443 blower mount.

that is, the Dayton 4C443 (100 CFM) and the Rotron V537A2R4 (160 CFM). Generally speaking, the more air flow the better, so the choice of blowers is usually a compromise based on noise level and price. The noise can be reduced appreciably by control circuits that reduce blower speed during standby periods. To make the blower operation foolproof (the amplifier will fail in less than a minute without air), an air switch can be mounted in the output air stream of the blower, or a pressure switch can be mounted on the upper chassis. These switches can be connected to shut down the power supply or bias the amplifier to cutoff (see next section).

power supply

The power supply was given a rather brief treatment in the previous article.[1] There's a tendency to consider the power-supply design and construction as less significant than the amplifier. This can be a mistake, especially for the tetrode screen supply which, as discussed previously, has critical requirements for successful operation of tetrodes. This time, to provide background on its operation, the power supply is described in some detail (see the schematic, **fig. 12**).

Features of modern high-voltage power supply

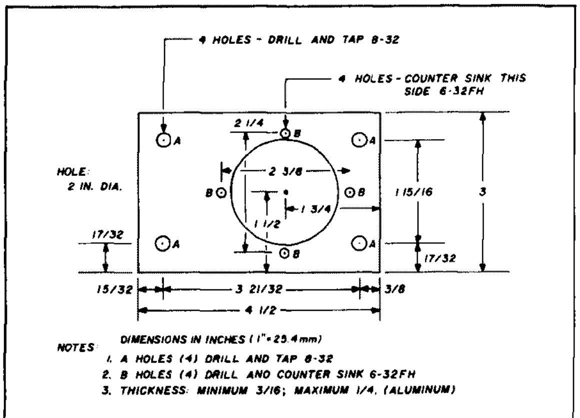


fig. 11. Air intake cover-plate (Rotron V537A2R4).

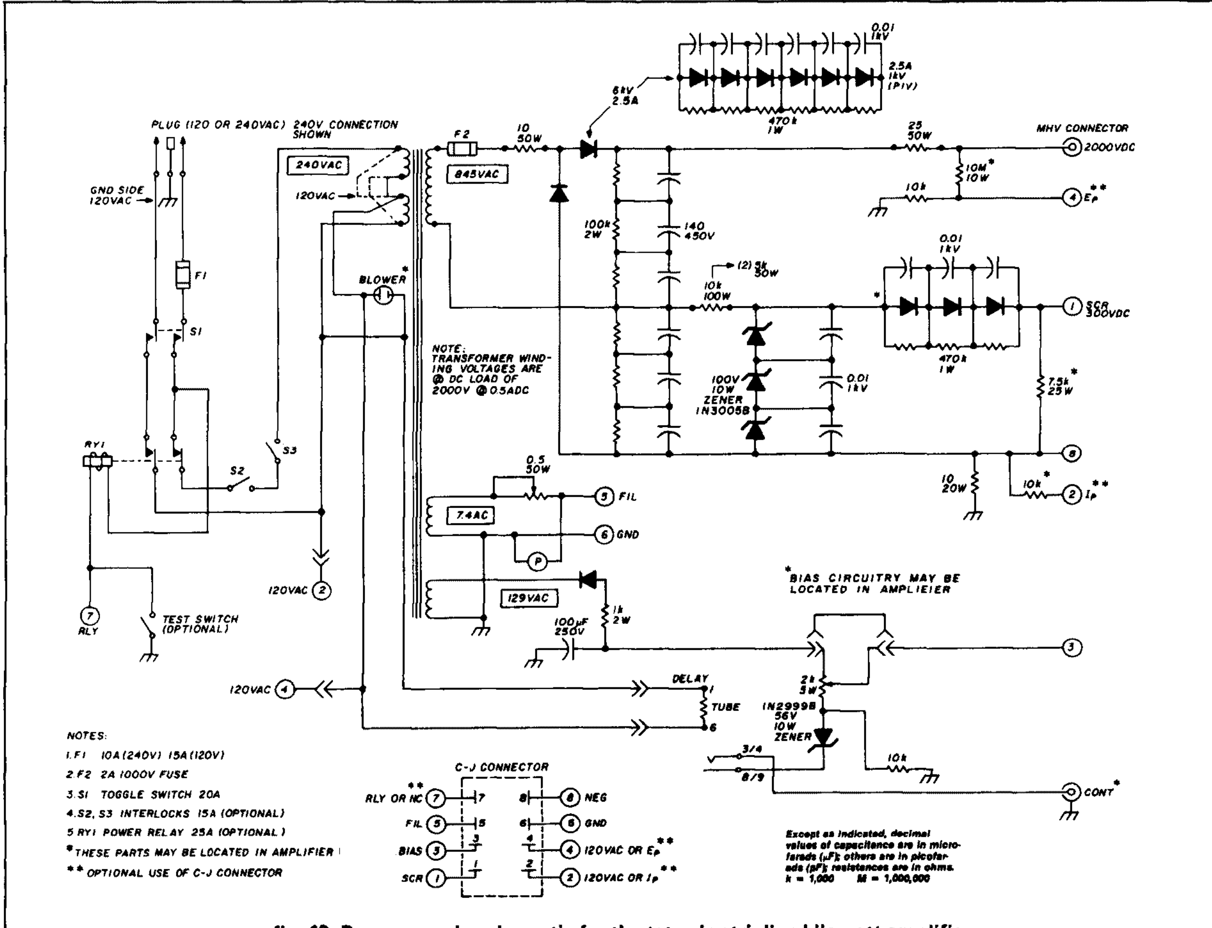


fig. 12. Power-supply schematic for the tetrode stripline kilowatt amplifier.

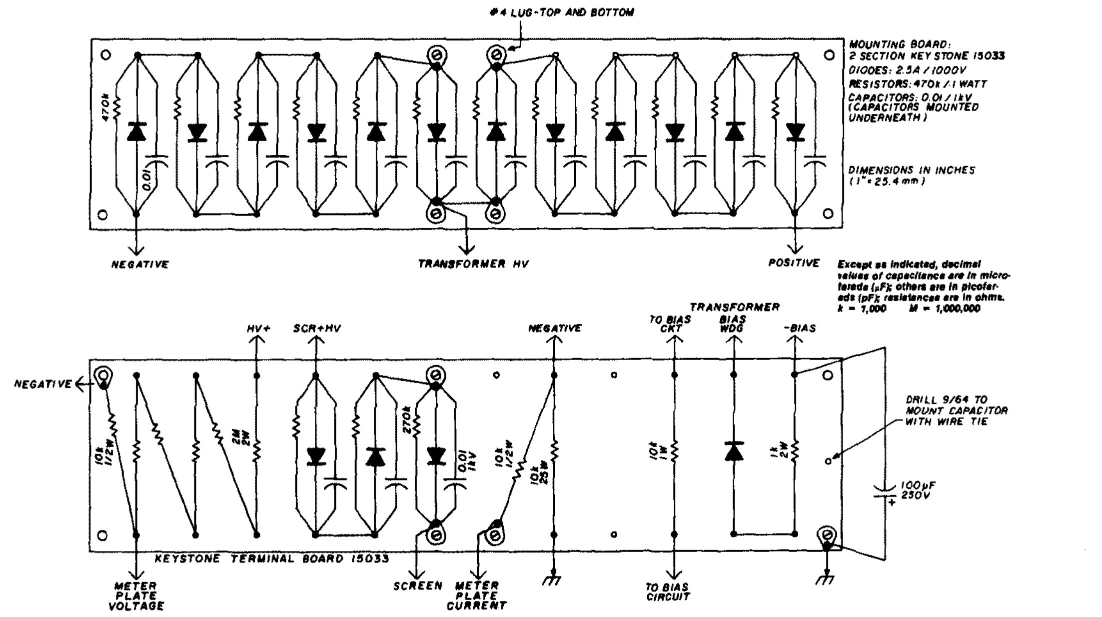


fig. 13. Details of the power-supply terminal strips. These two strips are mounted one over the other with 1-inch 6-32 spacers, with the high-voltage rectifier board toward the chassis.

design include compactness: 12 inches wide by 7 inches deep by 10 inches high (30.5 by 17.8 by 25.4 cm) and light weight (37 pounds, or 17 kg). All output voltages and other features to operate the amplifiers discussed above are provided. No-load output is 2300 volts dc. Outputs under loads of 1 ampere, 500 mA, and 100 mA are respectively 1850, 2000, and 2200 volts dc. Screen voltage is 300 volts dc regulated to 40 mA sink current. Cutoff and operating bias voltages are respectively −120 volts dc and −56 to −90 volts. (Operating bias is regulated at −56 volts dc.) Also provided are 7.6 volts ac, which is adjustable from 5.5 volts to 6 volts ac at 6 amperes. One-hundred-and-twenty volts ac are provided at the blower receptacle.

The transformer (custom manufactured by H. E. Johnson and Associates, Clearwater, Florida for ARCOS) has input provisions for either 120 Vac or 240 Vac, 50 to 400 Hz. Assembled around a 1540-watt hipersil core, the transformer is vacuum impregnated with insulating varnish then coated with a single-part thermosetting epoxy for mechanical protection. In ambient air of 25 degrees C with convection-radiation cooling only, continuous operation at 1000 watts dc results in a temperature rise of less than 30 degrees C.

The primary power circuit consists of a three-wire power cord, double-pole power switch, power relay (optional) and top and bottom cover interlock switches (optional). A test switch (also optional) simulates the ground for operating the power relay, which comes from the associated amplifier over pin 7 of the low-voltage connector. The power cord must be sensed correctly for this feature to work with the 120-Vac connection.

A blower receptacle is provided. The power cord from the power supply blower, which is mounted on top of the power supply, plugs into the blower receptacle. The blower cord has a bridged receptacle to which the amplifier blower can be connected. Alternatively, 120 Vac may be connected to pins 2 and 4 of the power supply's low-voltage connector for operating the amplifier from a receptacle on the amplifier chassis. If this option is chosen, metering resistors for plate current and plate voltage must be located in the amplifier instead of in the power supply.

A review of the schematic will show that a voltage-doubling circuit is used with over 30 μF of electrolytic capacitors in each leg of the rectifier circuit. Six 1000-volt PIV/2.5-amp diodes are used in series in each rectifier leg. The diodes are protected by a secondary fuse (2 amps/1000 Vdc) and a 10-ohm, 50-watt series resistor. The short-circuit current is limited in the high voltage lead by a 25-ohm, 50-watt resistor.

The voltage doubling circuit provides a 1000-Vdc output for developing regulated 300-Vdc screen

voltage (pin 1 of the low-voltage power connector) by using a series resistor and zener diodes. The zeners are protected from high-voltage transients on the screen leads from the amplifier by series diodes in the screen lead. The screen terminating resistor may be located either in the power supply or in the amplifier.

The screen series resistor and screen terminating resistor values were chosen to maintain regulation with a 40-mA sink current in the screen terminating resistor. Adequate sink current for the screen circuit is essential to the proper operation of tetrode amplifiers. The sink current path through the terminating resistor provides a bleed path for the reverse screen current, which is normal for tetrodes. As I mentioned previously, if an adequate bleed path is not provided, the screen voltage will attempt to rise to the plate voltage and the tube will go into a runaway condition unless protected by surge voltage protectors at the screen-socket terminals. The 40 mA sink current provided for the screen terminating resistor in this power supply meets the tube manufacturer's recommendation for at least 15 mA per tube.

The series diodes in the screen lead block any high-voltage transients, which can occur in the time interval it takes for the surge voltage protection to operate, from destroying the zeners used for regulation.

The blower, mounted on top of the power supply over the vent slots near the screen-series resistors, provides cooling for approximately 100 watts of heat dissipation from the screen circuit components.

The grid-bias voltage (pin 3 of the low voltage connector) is regulated by a zener and is adjustable by a potentiometer. A delay tube is used to delay operating bias on the amplifier during warm-up. The bias changes from cutoff (− 120 Vdc) to operate (− 56 to − 90 Vdc) when ground is placed on the control jack. Provision is made for metering plate voltage and plate current over pins 2 and 4 of the low-voltage connector (when these pins are not used, as described above, for 120 Vac to the amplifier chassis). Pin 5 of the low-voltage connector provides adjustable filament voltage to the amplifier. Pin 6 provides ground and pin 8 connects to the negative lead of the power supply. The high voltage is connected to the amplifier by RG-59/U coaxial cable using Amphenol MHV connectors.

The conductors between the amplifier and the power supply, other than the high voltage, are connected over an eight-conductor cable (Belden 8448) having one pair of No. 16 AWG conductors used for the filament voltage and ground. The other six conductors are No. 22 AWG.

Construction of the power supply is shown in the photos. The amplifier was assembled on a prepunched foundation chassis available from ARCOS. Diagrams of the terminal strips used to mount the high-voltage diodes, screen and bias circuitry, and so forth, are shown in **fig. 13**. Other construction details are included in **fig. 14.** There's nothing critical about parts location, so any convenient chassis arrangement may be used. Be sure to provide adequate ventilation for the screen resistors and zeners.

For use with the triode amplifier, the screen regulation and grid bias components are omitted (**fig. 15**). Note that the metering resistors for the triode amplifier are located in the amplifier.

test and operation

Connect the amplifier to the power supply and make the usual checks of blower operation, filament voltage, bias voltage, screen voltage and plate voltage. Set the bias for an idling current of about 100 mA for initial tests. Apply a watt or so of excitation and adjust the grid controls for maximum plate

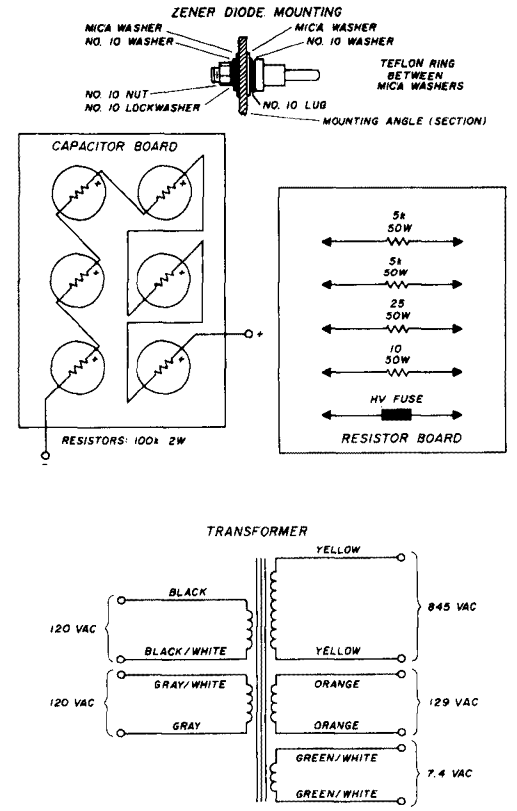


fig. 14. Construction details for the zener mounting, capacitor board, and resistor board in the power supply. The transformer is custom made for ARCOS by H.E. Johnson and Associates, Clearwater, Florida. Secondary ac voltages shown at a dc load of 2000 volts at 0.5 amp.

current. Then resonate the plate circuit by observing power output. If the plate circuit will not resonate, change the range of the plate-tuning flapper controls.

Increase drive until the output is at about 400 watts with the loading control about 1/8 inch (3 mm) above the top plate. Now set the grid controls for minimum SWR toward the driving source. Next, adjust the plate load and tune controls for a compromise between maximum output and minimum plate current at an output level of 500 to 600 watts. See **table 1** for a typical set of readings taken during the test of one of these amplifiers.

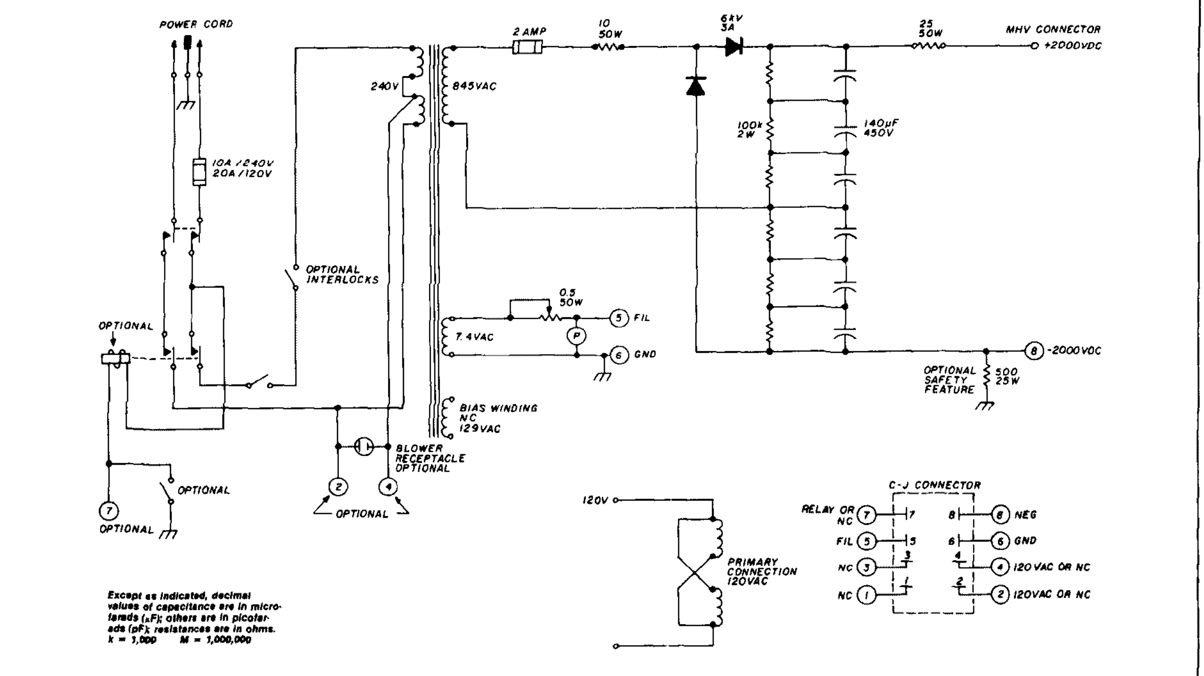


fig. 15. Schematic of the power supply for the triode stripline kilowatt amplifier.

table 1. Typical test results for the 220-MHz amplifier.

E_{fil} (volts)	E_{grid} (volts)	E_{scr} (volts)	E_{plate} (volts)	I_{grid} (mA)	$I_{scr\,1}$ (mA)	$I_{scr\,2}$ (mA)	I_{plate} (amp)	RFO	drive (watts)	output (watts)	input (watts)	temperature 1 (F)	temperature 2 (F)
5.9	−92	380	2350	—	—	—	.100	—	idling	—	235	128	128
5.9	−92	379	2200	0	−6	−2	.280	4	6	280	616	180	180
5.9	−87	378	2100	−1	−5	−1	.540	6	12	600	1134	170	170

tubes: 4CX250R
dummy load: 150 ft (46 meters) of RG-8/U terminated by a Heath Cantenna.™
operation: Class AB1

Notes:
1. Temperature 1 and temperature 2 refer to the temperatures at the two exhaust ports.
2. Efficiencies are 45 percent on line 2 and 53 percent on line 3.
3. RFO readings are the relative power output on the multimeter of the amplifier.
4. The negative grid and screen currents are normal for this type operation.
5. Observe the excellent screen voltage regulation.
6. Plate voltage regulation is 11 percent.
7. At 1-kW input the power output would be about 540 watts on CW for this operation condition.
8. SSB inputs can exceed the above figures somewhat if desired.
9. Key down on CW at 1 kW input, the tubes are within their dissipation rating (500 watts).
10. Power readings were taken with Bird 43 wattmeters in both drive and output.

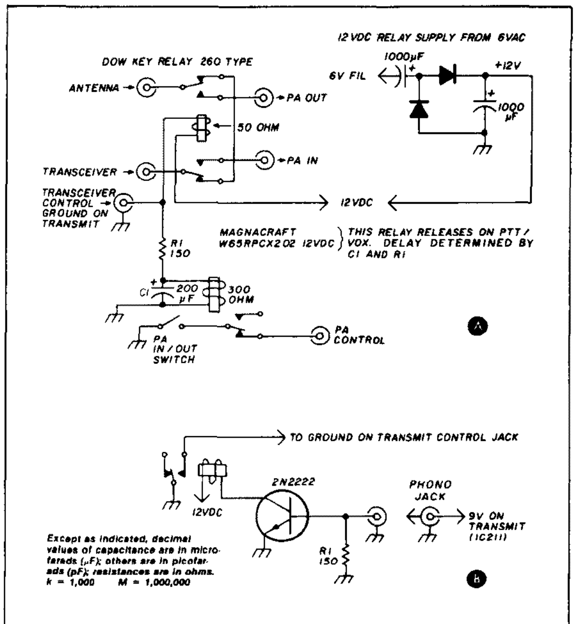


fig. 16. Antenna relay control schematic, A. Circuit prevents "hot" switching and also provides power-amplifier input-output control. Place a tab of cellophane tape on the pole piece of the Dow-Key 260 relay. B shows a circuit to adapt the ICOM or similar transceivers to furnish ground during transmit. The base circuit (R1) must be adapted to the application used.

A relative indication of the effectiveness of cooling, as well as the relative dissipation shared by the two tubes, can be obtained, as suggested by K2R1W[2] by mounting a candy thermometer over the air outlets. Temperatures read in this manner should not exceed 200 degrees F (93.5 C) under any condition. The thermometer is equipped with a pair of stiff wire legs, which faciliate setting it on top of the amplifier over the exhaust holes.

A failure of the air supply, if undetected, will result in a very rapid and disastrous temperature rise inside the plate compartment. Usually the solder on the plate line melts and the finger stock springs out to touch the chassis — grounding the high voltage and operating the high-voltage fuse. In cases observed so far, the tubes have survived. To prevent damage, an air switch in the blower or a pressure switch for the plate compartment may be used to shut down the power supply or bias the amplifier to cutoff when air pressure fails.

A suggested setup for switching the antenna when using a transceiver for drive power is shown in **fig. 16**. Some transceivers don't furnish ground on transmit, providing either 12 Vdc or some other voltage. There's not enough current available in some cases to operate a relay. A transistor and relay may be connected as shown in **fig. 16** to accept a voltage on transmit and produce a ground to operate the antenna-switching circuit. Note that a 12-Vdc supply is required for the above circuit. This may be obtained from the **6** Vac on the filament line as indicated.

references

1. Fred Merry, W2GN, "Stripline Kilowatt for 2 Meters," *ham radio*, October, 1977, page 10.

2. Richard T. Knadle, Jr., W2RIW, "A Stripline Kilowatt for 432 MHz," *QST*, April, 1972, page 48; May, 1972, page 59.

appendix

Errata in the October, 1977, article[1] on the two meter amplifier should be considered during construction.

Page 11 — fig. 1: "B" lead to meter switch is not shown. It is a direct lead from the opposite side of the 10-ohm metering resistor. (Opposite from the "A" lead.)

Page 12 — Caption on **fig. 3** should read 8930.

Page 13 — The caption of **fig. 5** is correct, but the drawing should be interchanged with that of **fig. 10.**

Page 13 — (fig. 4): The 3/8-inch dimension shown on the right side view should be 3/4 inches. The Dayton blower referred to in the text is model 4C012A. (The blower now recommended is Dayton 4C443. A different blower mounting plate is required.)

Page 15 — The dimension 1-7/8 inches (upper left) for the center line of the socket holes should read 1-5/8 inches.

Page 17 — (fig. 10): See note concerning page 13, **fig. 5** above.

Page 19 — (fig. 13): (upper right) — *the dimension not* shown for the self-crimping nuts on the lower piece of the plate line is 1/4 inch.

Page 20 — (fig. 14): Aluminum support block — the vertical holes in the block should be 1-1/4 inches apart (not 1-1/8). The width of the fixed plate-line capacitor plate is 1-1/8 inches, not 1-1/2 inches.

Page 21 — (fig. 15): The grid coil is three turns, 5/8 inches diameter, 3/4 inches long, No. 16 AWG.

Page 21 — (fig. 15): The butterfly capacitor mounts are made of G-10 glass epoxy laminate having a thickness of 0.06 inch.

Page 21 — The dimension between the holes in the copper strap is 2-9/16 inches not 2-9/32.

Improvements developed since the October, 1977, article was published:

1. Surge-voltage protectors were added to the screen terminals of each socket.

2. The output (load) flapper assembly has been strengthened by mounting it on a Teflon block. A large Teflon button is mounted in a hole in the load flapper on which the adjustment screw bears. The adjustment screw was changed to a 1/4-inch thread cap screw. With this arrangement, there is no strain on the center conductor of the output connector, and mechanical stability is achieved. The Teflon piece underneath the load flapper is not required.

3. In the original design, the plate-tuning flapper was quite close to the plate line at resonance, which resulted in a tendency for it to flash over when loading was too light. To provide additional clearance and smoother tuning control, a padder capacitor of the flapper type was added above the plate line opposite the plate loading capacitor.

4. The zener regulators in the power supply are protected from high-voltage transients on the screen lead by a string of diodes.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

I was young once and knew everything. One of my beliefs was in the honest-to-gosh reading of an SWR meter. You merely put it in the line to the antenna and this magical instrument would tell you just what was happening inside the coaxial line. It was all very simple. Fortunately, I learned rapidly, and in the process amassed six or seven SWR meters. It was always amusing to make SWR measurements on an antenna with one meter and then to repeat the measurements with another meter. It was almost possible to hand-pick the SWR curve I wanted by the correct choice of instrument, since they provided widely different readings.

I'm not the only Amateur who has been led down the daisy path by the SWR meter. The complications associated with this interesting device are more important today than ever before because of the advent of the solid-state, high-frequency transceiver.

the more you have the less you get

Most high-frequency transmitters that have a solid-state power amplifier incorporate a protective circuit that will gradually turn off the amplifier as the SWR on the antenna system rises. Since most antennas are single-frequency devices (that is, adjusted at one spot in a particular band), a low value of SWR is obtainable at only one frequency. Operating the antenna off frequency causes the SWR on the feed system to rise, even though the antenna may work in excellent fashion across the whole band (**fig. 1**).

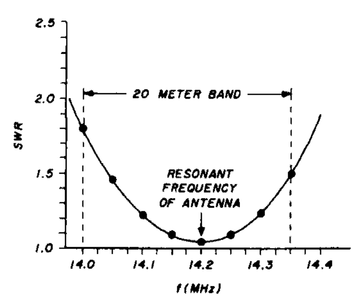


fig. 1. Idealized SWR curve of 20-meter antenna. Resonant frequency is 14.2 MHz. Antenna is matched at this frequency and the SWR is very nearly 1-to-1, rising rapidly as antenna is operated off frequency.

Tube-type amplifiers with their adjustable output controls (TUNE and LOAD) can adapt themselves to wide variations in the SWR of the antenna system. The solid-state wide-band amplifier, on the other hand, requires protection against SWR excesses. Hence the fail-safe shut-down design. When the SWR starts to rise, the amplifier transistors are electrically derated for protection.

All well and good, I say, but the user of such equipment must pay attention to the SWR across his band of operation, or he will find that he can get full power output from his rig only over a small portion of the band. This vexing problem is particularly true on 160, 80, and 10 meters, where the width of the band is large in proportion to the center frequency.

enter the SWR meter

To determine just what is going on with regard to a particular antenna, an SWR meter is commonly used to gain a picture of SWR vs frequency, as shown in **fig. 1**. But is this a true picture of what is happening? Possibly not. A knowledge of the workings of the SWR meter and its use are of utmost importance.

Most modern SWR meters are composed of two directional couplers built into one case. A single indicating meter is switched between the couplers and the meter is usually calibrated directly in terms of SWR (standing wave ratio).

A directional coupler is a device which samples power flowing in one direction in a transmission line but is insensitive to power flowing in the reverse direction.

If the antenna exactly matches the characteristic impedance of the transmission line and also matches the line

with respect to balance, it will absorb all power transmitted down the line. If a mismatch exists at the antenna, a certain portion of rf power will be reflected back down the line toward the transmitter.

The circuit in the directional coupler picks up energy from the line by means of both inductive and capacitive coupling. The inductive current in the line flows according to the direction of the traveling wave producing it. Thus there can be direct and reflected waves passing through the coupler. The capacitive pickup, however, is independent of the direction of the traveling waves, and the sum of coupled currents in the device produced from the waves of one direction will add in phase. Those produced from waves of the opposite direction will subtract in phase.

The electrical balance of a coupler is such that the current induced from the reverse-traveling wave will cancel the other completely, or nearly so, resulting in a directivity factor in the coupler. This means the coupler is highly insensitive (nulled) to a wave traveling in the reverse direction. Thus the device is sensitive to only one of the traveling waves which produces standing waves by interference. To determine SWR it is necessary to read forward and reverse (incident) power flowing in the line. Two couplers, reverse connected, can do the job (**fig. 2**). In order to obtain accurate readings, both couplers must be identical. And each coupler should be insensitive to power passing through it in the unwanted direction.

The important characteristic of a coupler is the ratio of the measurement in the forward direction to that in the reverse direction. If the coupler is sensitive to the unwanted reading, the accuracy of the coupler is seriously affected. When two couplers are used to make up an SWR meter, the problem is compounded.

A good laboratory-type coupler will have a directivity of better 25 dB, indicating that the coupler provides 25 dB of discrimination between opposite directions of power flow. An SWR meter made up of two such couplers provides an indicated value of SWR differing from the true value, as shown in **fig. 3**. As an example, a true value of SWR of 1.5-to-1 on a transmission line can provide an indicated value on the SWR meter which can vary between the extremes of 1.23-to-1 and 1.8-to-1. And most cheap CB-type SWR instruments are not this accurate.

Added to the directivity limitation, most inexpensive SWR meters have a built-in error because of the nonlinearity of the diode used to provide voltage for the indicating meter. At low voltage levels where the SWR reading is of the greatest importance, diode linearity is poorest.

Finally, all directional couplers are sensitive to second harmonic voltage that may exist in the antenna circuit. Since the antenna is mismatched at harmonics, it is possible for high SWR to exist at a harmonic frequency and if the coupler is accidentally placed at a point in the line having high harmonic current, pickup of this current will adversely affect the reverse reading of the coupler.

You may scoff at this notion, and say that the second harmonic level of your transmitter or exciter is "down 35 dB," or some such number. Well and good, but just remember that with a high value of antenna mismatch reflection at a harmonic, the harmonic voltage passing through the coupler may be many times higher than you suppose. And don't forget that when a coupler is measuring the reflected wave in a line, it may be measuring as high as 40 to 50 dB below the fundamental signal level. That is to say, the unwanted harmonic voltage can easily be of the same order of magnitude as the measured reflected wave.

For best results, therefore, I suggest you buy the best SWR meter you

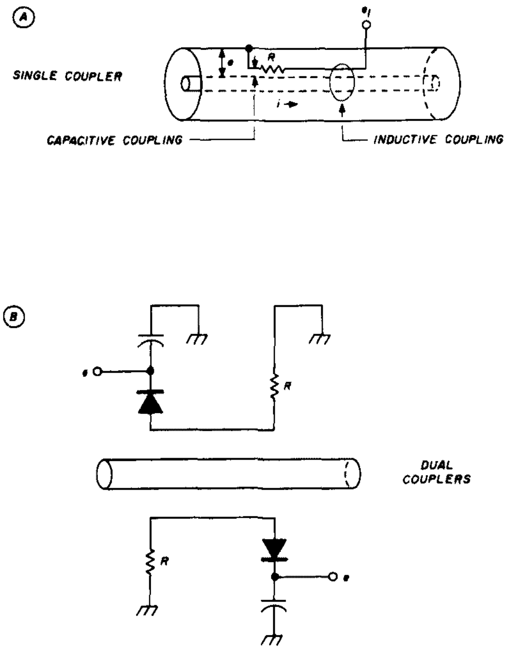


fig. 2. The directional coupler can sense either the forward or reflected wave components in a transmission line by taking advantage of the fact that the reflected components of voltage and current are 180 degrees out of phase, while the forward components of voltage and current are in phase. A short section of line coplanar with the inner conductor of the main transmission line (A) is formed into a loop through a series resistor. Voltage across the series-connected loop and resistor is measured, the combination constituting a short, terminated transmission line. The pickup device is sensitive to waves traveling in one direction by virtue of capacitive and magnetic coupling. The coupler may be rotated physically 180 degrees to pick up waves traveling in the reverse direction. An alternative is to employ two couplers built in one unit but oriented oppositely (B). Ideally, both couplers should be identical in coupling to the coaxial line and in directivity.

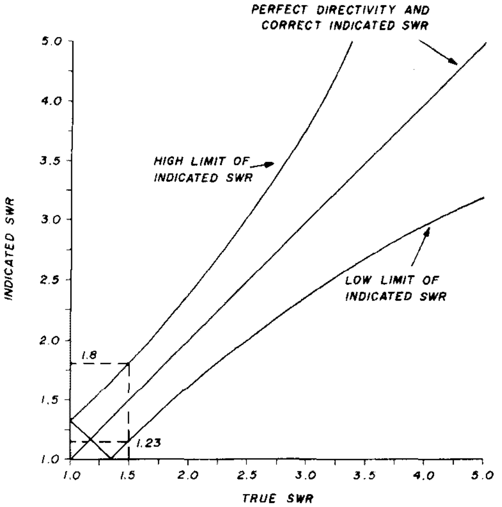


fig. 3. Extreme limits of indicated SWR versus actual SWR for a coupler having 25 dB of directivity. (Adapted from "Possible Errors in VSWR Measurement," Breetz, *QST*, November, 1959.)

can afford. Some SWR meters are made up of two directional couplers, back to back. Others have a single coupler with a reversible element. I prefer the latter type. One coupler made in the U. S. A. has plug-in heads for various frequencies and power levels. It is useful for both hf and VHF antenna measurements. While I don't believe in "plugging" name brands in this column, be assured this high-flying instrument is really a Bird!

pitfalls in making SWR measurements

So now you have a good SWR meter! Congratulations. If you use it properly, you'll get meaningful information. But you just can't jam it into a coaxial line and expect the instrument to do its job. It is up to you to make sure that the meter reads what you are looking for (true SWR of the antenna) and not a jumble of information resulting from unwanted coupling between the transmission line and the antenna. Let me explain.

Any conductor in the field of an antenna is coupled to it inductively. The degree of coupling depends upon the position of the conductor with respect to the antenna and the distance between antenna and conductor. A good example of such a conductor is a parasitic element in a beam antenna. It is closely coupled to the antenna and tuned closely to its frequency.

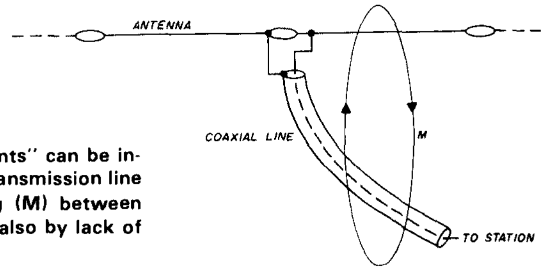


fig. 4. "Antenna currents" can be induced into shield of transmission line by inductive coupling (M) between line and antenna and also by lack of balun at the antenna.

Other conductors coupled to your transmitting antenna are overhead power lines, telephone lines, and your transmission line.

Yes! The outer shield of a coaxial line can be inductively coupled to the antenna if it runs parallel, or nearly so, to the antenna and is elevated above ground level. An example of this is shown in **fig. 4**, a typical antenna installation.

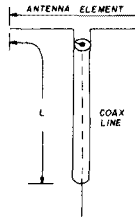
Antenna current induced on the outer shield of a transmission line will influence the SWR reading of currents within the line, as the outer shield is no longer at ground potential, even though the SWR meter and transmitter are supposed to be near ground potential. The outside of the coax line has become part of the antenna system (due to inductive coupling to the antenna) and thus becomes part of the load on the line, in addition to the antenna load. The SWR on the line is now determined by the composite load of the antenna and the outside of the line.

This is one reason why changing the length of the transmission line changes the SWR reading. The portion of the load caused by unwanted line coupling is being changed!

how to reduce unwanted line currents

To achieve an accurate SWR reading on your transmission line it is necessary to detune and decouple the line from the antenna. Certain lengths of transmission line, as measured between one tip of the antenna and the SWR meter (L) are not resonant in the Amateur bands (**table 1**). Cutting the transmission line to rec-

table 1. Recommended non-resonant transmission line lengths (L) for the high-frequency Amateur bands. Lengths indicated include distance between one tip of driven element and feed point, plus coaxial line length.



23 - 30 ft.	158 ft.
35 - 44 ft.	164 ft.
46 - 47 ft.	
52 - 63 ft.	
71 - 81 ft.	
86 - 90 ft.	
93 - 97 ft.	
106 - 112 ft.	
141 - 147 ft.	

(Adapted from *The ARRL Antenna Book*)

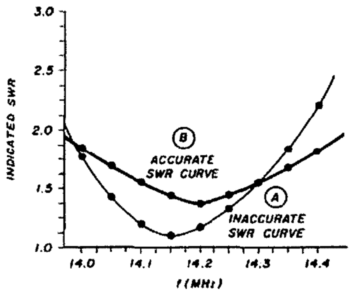


fig. 5. (A) Measured SWR curve with unwanted antenna currents flowing in outer conductor of coaxial line. Curve indicates antenna system resonance near 14.15 MHz with very low SWR. The more accurate curve run with antenna currents on line suppressed shows a flatter response, with higher value of minimum SWR at 14.225 MHz. Classic curve of measurement A may lull Amateur into thinking he has a perfect match, whereas the correct curve (B) shows match is not quite so good.

ommended lengths helps, but is not a total cure to the problem.

Of equal importance is the fact that the transmission line should not run parallel to the antenna elements. And it should be positioned close to the ground and not suspended above the ground. This is a large order when a rotary beam is used because at some beam heading the antenna elements will probably run parallel with the transmission line. The best solution is to run the coaxial line along the ground from the antenna tower to the station, or bury it beneath the ground in a section of water hose. The worst thing is to run the coaxial line a long distance above the ground from tower to station (along the roof top, for example). This places the coax line up in the air and closer to the active antenna.

But what do you do when it is impossible to cut line length to a recommended value and the line must run along the rooftop in the vicinity of the antenna? Obviously, induced antenna currents are going to flow in the outer conductor of the line. How can SWR measurements made under these conditions be trusted?

decoupling the transmission line

Let's assume that your situation is this: You have a tri-band beam for 20-15-10 meters atop a 40 foot tower. The coax feedline runs down the tower to the 10 foot level and then runs along your roof for about 20 feet to the station, then drops down to near ground level, entering a window near the transmitter. You make SWR measurements across each band and get a reassuring set of curves that bear a little resemblance to the "typical" curves supplied by the manufacturer. How can you determine your curves are valid?

The easiest and quickest check is to add four or five feet of coaxial line between the SWR meter and the antenna and rerun the SWR curves. If the shape or amplitude of the SWR curves change, it is a good bet that you have unwanted coupling between the antenna and transmission line. Of course, to make this experiment, it is understood that the unbalanced, coaxial line is properly terminated at the antenna in a balun or other device which provides a match between the unbalanced line and the balanced driven element of the beam. (Note: Such a test is valid *only* if you have a good SWR meter.)

If you find that interaction between line and antenna exists and it is impractical to move or otherwise change position of either the line or the antenna, what is to be done?

One helpful and easy thing to do is to coil the line into a simple rf choke at the foot of the tower. Four or five turns about a foot in diameter, taped together with electrical tape, will help to "cool off" the line at the tower.

At the station end of the line, a second, similar coil may help solve the problem. The coil can be made by splicing an extra length of line into the system with coaxial adapters. After the coils are in place new SWR runs are made, with and without the extra spliced-in line section. Now, do

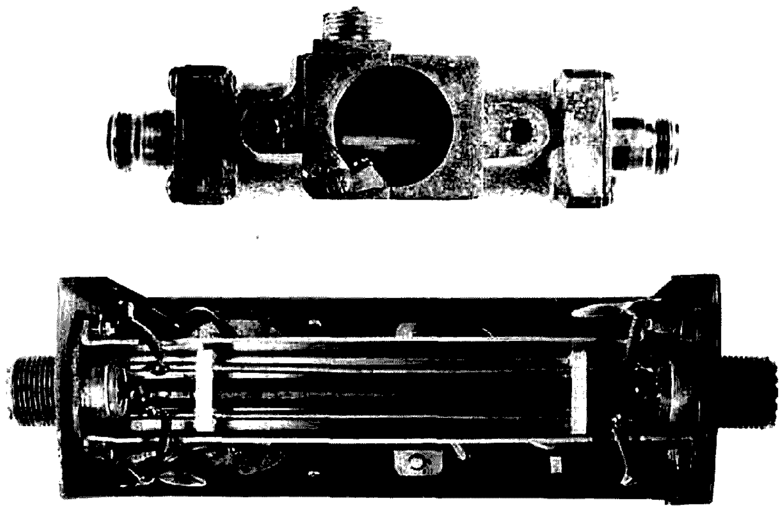


fig. 6. Bird coupler (top) is machined from solid brass casting. The coupling element is plugged into hole at center of the structure. Center conductor of coaxial line can be seen running through the center of the coupler. Voltage pickup is taken from fitting on side of the casting. Inexpensive "CB-type" SWR meter (bottom) has two directional couplers made up of wires placed parallel to center conductor of open coaxial line section. Open trough with one side exposed permits antenna currents flowing on outside of the coaxial line to enter the measuring section of the line where the coupling elements are located.

the two sets of measurements agree within reason? If they do, your transmission line is decoupled from the antenna (**fig. 5**). Don't expect the curves to match exactly; a degree of line coupling can still exist, particularly if the transmitter or exciter are enclosed in a "leaky" cabinet that permits rf to pass from the transmitter circuits to the outside of the cabinet (most of today's modern transmitters fall into this regrettable category).

a final word on SWR meters

The name of the game is to keep all the rf bottled up inside the transmission line up to the antenna and let none of it escape along the outside of the coaxial line. This will provide the most reliable SWR indication. But all your good efforts may go for naught if you choose a poor SWR meter! Look at **fig. 6**. This photo compares the directional element of a Bird coupler with an inexpensive, imported "CB-type" SWR meter. Note that the coupling element of the cheap device is an open trough, with one side exposed, providing excellent coupling between the wanted measurements and any induced waves traveling along the outside of the coaxial line. The break in the line shield inside the SWR meter provides a perfect place for transmission line currents and unwanted induced currents to join — right at the point the measurement is being taken.

Don't throw out your cheap SWR meter, but don't put too much trust in it. Borrow a good directional coupler and place it in series with your SWR meter. See how the two compare in readings across your antenna's span of operation. Decouple your transmission line by keeping it close to ground level and winding it up into rf chokes at the station and tower ends of the line. Make sure you use a good balun at the antenna, if one is required.

More in my next column.

ham radio

For more information on the use of the SWR meter, the reader is referred to the just-published 22nd edition of the *Radio Handbook*, available from Ham Radio's Bookstore. Editor

2716 EPROM programmer

Easy method for burning EPROMS with your microprocessor

Programming read-only **memories** (ROMs) is a virtual necessity if you're developing microprocessor-controlled ham gear. Many microprocessor systems, such as the KIM, SYM, and AIM, are capable of developing and debugging simple control programs, but none have ROM programming capability. As a first step to integrating microprocessor control into my projects, I found that I needed something to go with my KIM that would program and read erasable programmable read-only memories (EPROMs). The circuits presented here will work with the KIM, SYM, and AIM and are adaptable to other microprocessor systems.

what is an EPROM? why program one?

Solid-state memory for microprocessors comes in two forms, random-access memory (RAM) and read-only memory (ROM). The former is a general-purpose memory that can be used to store both program and data material. Information stored in it may be changed at will.

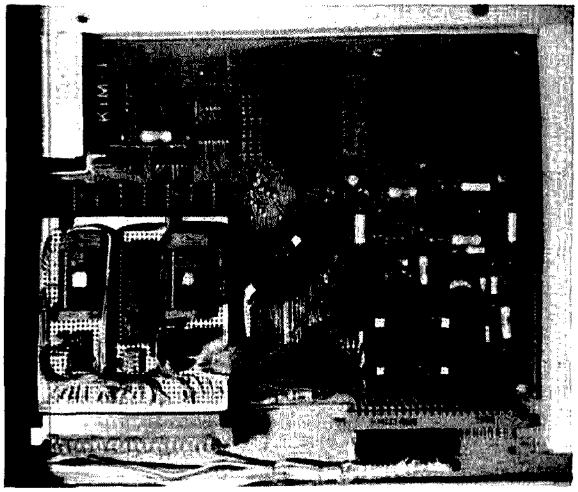
ROM is used for permanent programs and their constants. As the name implies, it can be read only. If scratch pad space beyond that contained in the microprocessor is required, it must be supplemented with RAM.

The shortcoming of RAM is that it is volatile; that is, if the power is removed the RAM forgets. Many schemes for making RAM more permanent are available, such as battery or large-capacitor power supply backup, but in the long run permanent programs should be stored in some sort of nonvolatile ROM. This places them beyond the reach of power failure and programming errors, which would leave a RAM filled with garbage.

An additional advantage of ROM is that microprocessor chips, when powered up, awaken seeking the address of their first instruction at a particular location. If the program stored in the ROM has the correct addresses, pointing the way to the beginning of the program, the routine will be self-initiating when powered up. In other words, the operator doesn't even have to know that a microprocessor is there.

ROMs fall into different categories depending on their application and the volume of their manufacture. The particular chip considered here, a 2716, is selected based on its popularity and price. The 2716 is an erasable programmable read-only memory (EPROM) with 2K (2048 bytes) of memory. It may be programmed with simple circuitry and straightforward techniques.

To correct mistakes, or when you wish to replace an old program with a new one, the chip can be erased by exposure to ultraviolet light.* Program-



The completed unit. The PPI is the large IC in the center of the board. The programming socket is to its right and the read socket to the left. The regulator with a heatsink is mounted vertically at the bottom right corner of the PPI. The regulator bypass capacitor is between it and the battery connectors.

*Commercial UV erasers are available from computer hobbyist supply houses for $65 to $75. A simple home-built eraser is described by Golter, "Build a Low-Cost EPROM Eraser,", *BYTE*, April, 1980.

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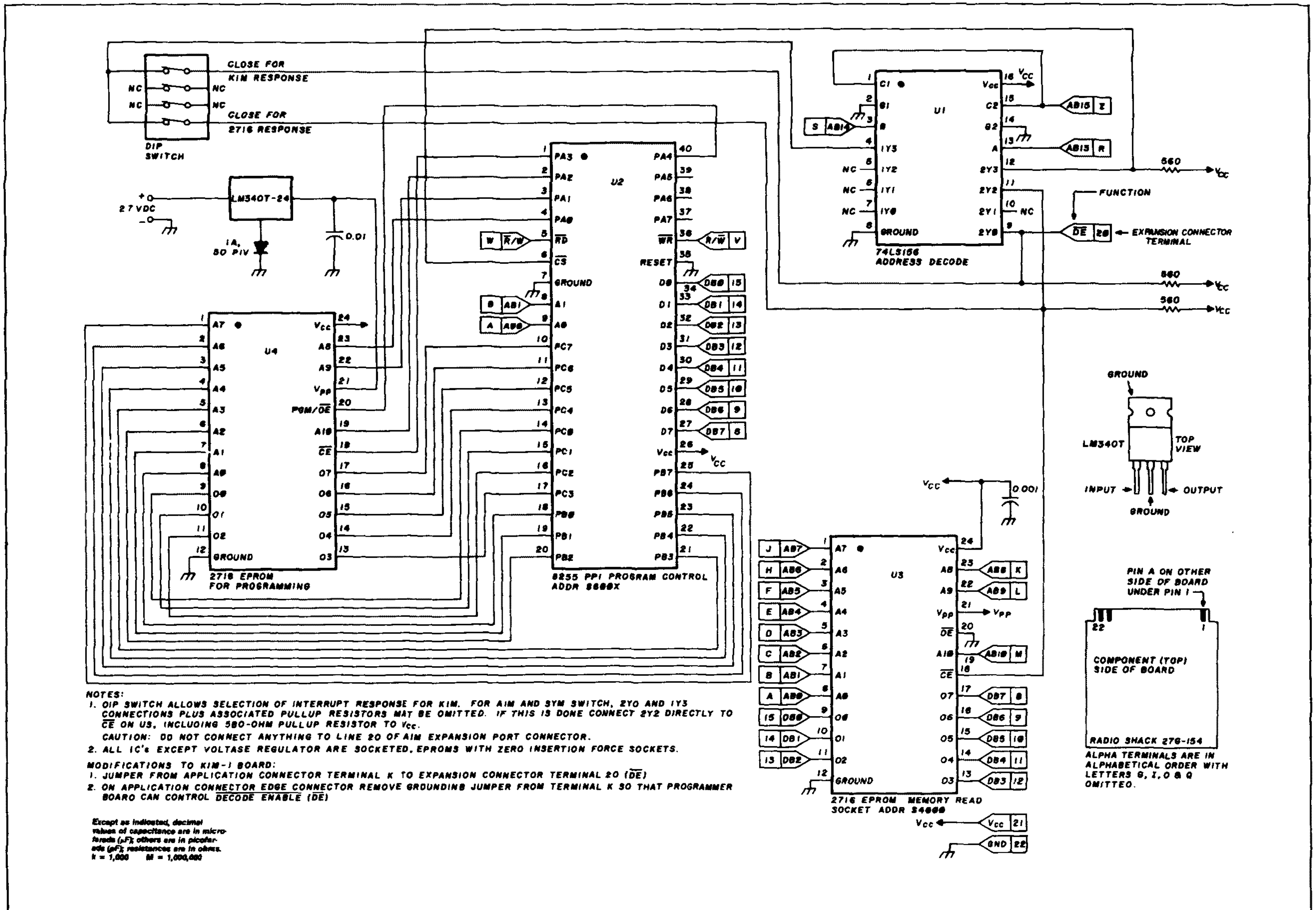


fig. 1. Schematic diagram of the 2716 EPROM programmer-reader.

ming can be accomplished a byte at a time, or the entire EPROM may be programmed at once. Unfortunately, during erasure, everything gets erased together.

how it works

The basic programming circuit is built around an 8255 programmable peripheral interface chip (PPI). The 8255, designed for compatibility with the 80XX line of microprocessors, is easy to interface and has sold in sufficient quantity to be economical for Amateur use. It can be addressed by the controlling microprocessor bus and directed to either read from or write to its input/output lines, providing communication with the EPROM being programmed.

The microprocessor board supplies the byte address of the location in the EPROM being programmed, the data to be recorded and the enabling signal. Programming all of the 2048 EPROM locations at one time requires about 103 seconds, or 50 milliseconds per location.

Programming a 2716 EPROM requires a 25-volt positive signal. This voltage is derived from a 24-volt LM340T monolithic regulator chip, as shown in **fig. 1**. A diode in the regulator's reference leg increases the output to approximately 25 volts. The chip is powered by three 9-volt transistor radio batteries connected in series. Though not elegant, the technique is quite effective for small volume use.

The microprocessor chips used in the KIM, AIM and SYM circuits have a pull-down-to-reset signal, which is not directly compatible with the 8255 chip (pull-up to reset). Rather than add an additional IC to provide the extra gate needed for hardware reset, I decided to do it with software. This is accomplished by converting all of its ports to inputs with a control instruction before connecting the batteries to the 24-volt regulator.

The programming algorithm includes a testing operation before programming to ensure that the EPROM area to be used is clean (all bits set to logical ones — the erased condition). The algorithm also contains a second comparison routine after programming to ensure that data transcription is correct. **Fig. 2** is a flow chart showing the initial verification and programming. The final comparison uses similar technique.

I selected the addressing of the PPI and 2716 EPROM read socket to be compatible with the SYM, AIM, and KIM microprocessor boards. On the first two these addresses are mapped into the user expansion space. On the KIM they fall above the monitor.

Both the PPI and the EPROM read socket must be enabled; that is, told when to respond to address and data bus inputs. This is accomplished by applying a logical zero (low level) signal to the NOT chip enable

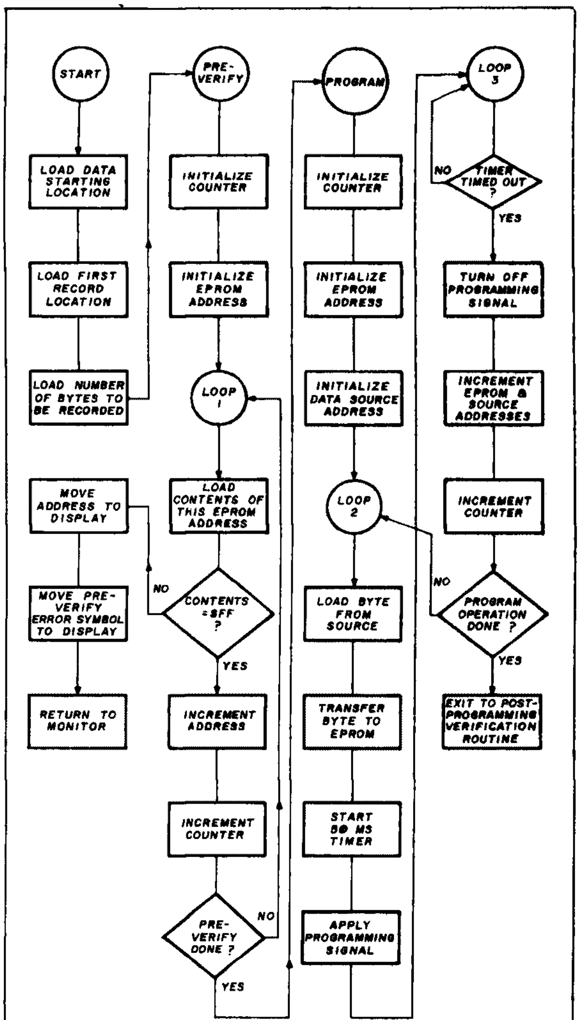


fig. 2. Flow chart of pre-verify and programming routines. Post-programming verification is similar to pre-verify except that the EPROM is checked against its source.

($\overline{CE}$) line of the selected chip. A 74LS156 three-to-eight line open collector decoder performs this selection by address decoding. It breaks the 64K addressing capability of the microprocessor into eight 8K segments as shown in **fig. 3**. The NOT 8K segment 3 line ($\overline{8K3}$) is assigned to the PPI and the $\overline{8K2}$ line is assigned to the EPROM read socket.

Beyond this point the KIM differs from the SYM and the AIM. The latter two fully decode the portions of memory that they use internally, whereas the KIM does not have this feature. Without outside help it can't tell one 8K segment from another. The KIM's NOT decode enable ($\overline{DE}$) must be brought low only when its on-board devices are to respond to an address on the address bus. To permit this action the $\overline{8K0}$ and the $\overline{8K7}$ lines from the 74LS156 decoder are

wire-OR tied (paralleled — see fig. 3) together. The first of these picks up on-board KIM devices during normal addressing, and the latter allows interrupt responses.

This occurrence gives rise to an interesting opportunity for the KIM user. If the $\overline{8K7}$ line is instead wire-OR tied to the EPROM read socket, the resident EPROM will respond to interrupts. To permit this, a DIP switch is included on the board to control which device gets the $\overline{8K7}$ enabling signal. As mentioned above, this applies only to the KIM.

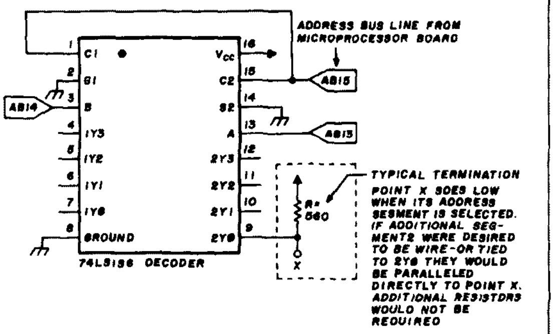
Note that if circuitry is set up for use with the KIM, it may be used on AIM and SYM systems with the following provisions:

1. The EPROM read socket must not be selected as the interrupt source. If it is, bus contention will result when both the host board and the EPROM try to respond to $\overline{8K7}$ addresses on read cycles.

2. Line 20 on the expansion connector must be left open with the AIM.

The AIM 65 uses this connection for other purposes. Alternatively, AIM and SYM users may omit the connections to the $\overline{8K0}$ and $\overline{8K7}$ lines, the associated resistors and the DIP switch.

You will notice that this is a fairly wasteful method of addressing. The PPI uses only four addresses out of the 8K available to it. The EPROM read socket uses only 2K of its 8K. I found no use for the additional possible PPI addresses, but the EPROM addresses are a different story. The price of 2732 EPROMs (4K byte EPROMs) are today about half of what 2716s cost two years ago. I expect that before long I'll modify the programming board to handle 2732s and possibly 2764s. They are virtually identical to the 2716 and require minimal circuit changes



SEGMENT	74LS156 PIN	HEXADECIMAL ADDRESS RANGE FROM	TO	COMMENTS
8K0	2Y0	0	1FFF	USED FOR KIM ON-BOARD DEVICES
8K1	2Y1	2000	3FFF	—
8K2	2Y2	4000	5FFF	EPROM READ SOCKET ENABLE
8K3	2Y3	6000	7FFF	PPI ENABLE
8K4	1Y0	8000	9FFF	—
8K5	1Y1	A000	BFFF	—
8K6	1Y2	C000	DFFF	—
8K7	1Y3	E000	FFFF	USED FOR KIM INTERRUPT RESPONSE

fig. 3. Address decoding arrangements used for chip enable of PPI and EPROM read sockets.

construction

The unit is assembled on a Radio Shack two-voltage edge-card board, part no. 276-154. I selected this board because it has an edge connector matching that found on the KIM, SYM, and AIM systems. Those with a different type of microprocessor system may choose alternative boards better suited to this application.

All ICs except the voltage regulator are socketed. The sockets make modifications easier and let you remove static-sensitive MOS chips when the board must be handled. For the EPROMs, zero insertion force (ZIF) sockets were selected to minimize wear and tear on the 2716 chips. The ZIF sockets are wide enough so that they overhang the outermost connections for each pin on the programmer board, which means that the wiring must be completed before installing the ZIF sockets. Advance planning in the wiring layout is necessary to keep it from obstructing ZIF socket installation.

A four-unit DIP switch was selected to control decoding for top-end-of-memory addressing. A conventional toggle switch could be substituted, but the DIP switch fits more neatly into the board layout. These switches are needed only if KIM compatibility is sought.

All wiring and components are located on the blank (non-foil) side of the board. Install short jumpers for V_{CC} and ground connections before wiring the longer runs.

Jumper cables with suitable connectors are available* to connect the boards together but they are considerably longer than my layout required and they're expensive. I obtained wire-wrap connectors at a hamfest and hand wired them together instead. I mounted the programmer board quite close to the microprocessor board to minimize reactance and crosstalk. The wiring between the connectors is 1-1/2 inches (4 cm) long. After wire wrapping the connectors I applied a liberal coat of silicone rubber sealer to keep repeated installations and removals from loosening the wraps.

The KIM expansion connector contains all the necessary lines except the $\overline{DE}$ line. Fortunately, there are unused lines on the expansion connector, termi-

*Available from the Computerist, Inc., Post Office Box 3, South Chelmsford, Massachusetts 01824. Program documentation and programmed EPROMs are available from the author. Send an SASE for information.

nals 18, 19 and 20. I wired the DE line from the application connector's terminal K to terminal 20 on the expansion connector with an on-board jumper. No board changes are needed on the SYM or AIM.

The regulator chip probably doesn't need a heatsink at the currents drawn during programming. If one is handy in the junk box, however, there's certainly nothing lost in installing it.

The batteries are connected using 9-volt battery connector leads. When not programming EPROMs the batteries should be disconnected and may be relegated to the refrigerator to prolong their life.

Both the jumper lead on the microprocessor board and the battery connector leads on the programmer board should be anchored with spots of silicone rubber sealant, which prevents placing mechanical stress on their solder joints.

notes on components

The basic cost of the parts for this board is about $34, which includes the two ZIF sockets but does not include connectors or 2716 EPROMs. Comparable EPROM programming systems available commercially start around $80. Many run in excess of $200 wired, although the higher end boards usually have multiple EPROM read sockets and may perform other functions such as handling memory expansion as well.

The more exotic chips used here (the 2716s and the 8255) were picked up from mail-order suppliers. Most of these accept phone orders for credit-card billing and feature 48-hour order turn-around via UPS. A sample of five suppliers of 8255s from the July, 1981, issue of *BYTE* magazine shows a unit price range from $5.40 to $9.95.

initial operation

Check the wiring to make sure its correct and that no shorts or solder bridges exist before applying power. My original wiring was all right, but apparently I'm losing my color vision: one resistor was the wrong value.

With both EPROM sockets empty, connect the board to the microprocessor system's expansion connector (with the system de-energized, please!). Fire up the microprocessor and direct the 8255 PPI to output logical ones to each of the programming socket's pins, one at a time. Check operation with a voltmeter. Note that KIM and similar systems can't write to the PPI manually because the monitor tries to treat the PPI as a read/write memory. Things get snarled up with the monitor when it tries to read back what it's just written. To write to the PPI, a store absolute instruction (or its equivalent) must be used.

I've encountered only one hardware problem since startup (my software is always full of bugs). During an EPROM read, one or more bit at one or more addresses would occasionally be wrong. To the best I've been able to determine, this was due to low power-supply voltage (about 4.75 volts on the EPROM board). I corrected this by installing a 0.001 μF bypass at the read socket's V_{cc} pin and by cranking the power supply up to 4.98 volts under load.

Table 1 lists the rules for using the PPI to talk to the programming socket as they apply to this circuit. Carefully step through your algorithm before applying programming voltages to an EPROM, and make sure that the 50-millisecond period falls somewhere between 45 and 55 milliseconds. Periods under 45 milliseconds may give incorrect programming, and over 55 milliseconds may leave you a dead EPROM!

An additional consideration on the EPROM programming side is that the manufacturer's data sheet requires application of V_{cc} (+5 volts) before applying V_{pp} (+25 volts) and removing V_{pp} first (concurrent application and removal are also permitted). To avoid getting into trouble, don't connect the batteries until you are ready to program, and disconnect them just as soon as you are finished.

table 1. Rules for PPI programming.

function	PGM/$\overline{CE}$ port line PA3 (2716 Pin 18)	$\overline{OE}$ port line PA4 (2716 Pin 20)	2716 response
program	_⎍_	1	program data in
program inhibit	0	1	high Z outputs
program verify	0	0	data out

8255 PPI control for this circuit

control addresses:
- $6000 = port A
- $6001 = port B
- $6002 = port C
- $6003 = control word register

control words:
- $80 = make all ports outputs (for programming)
- $9B = make all ports inputs (resets PPI and applies no signals to EPROM)
- $89 = make ports A and B outputs; port C an input (for verify)

port assignments:
- port A = EPROM address lines A10 through A8 correspond to port lines PA2 through PA0, EPROM $\overline{CE}$ to PA3, EPROM $\overline{OE}$ to PA4
- port B = least-significant address byte
- port C = data bus

Once everything checks out, you're ready to go. Remember in use that the 8255 PPI and the 2716 are static-sensitive devices and may be ruined by improper handling. Follow manufacturer's recommendations and use an insulated insertion/extraction tool to handle the devices.

ham radio

performance capability of active mixers

Part two: practical circuits and testing

In the first part of this article, I introduced the basic characteristics that distinguish active double-balanced mixers. The equations that define the sigificant interfering effects during signal handling were also developed. Now we will look at some practical mixer circuits and examine some testing techniques.

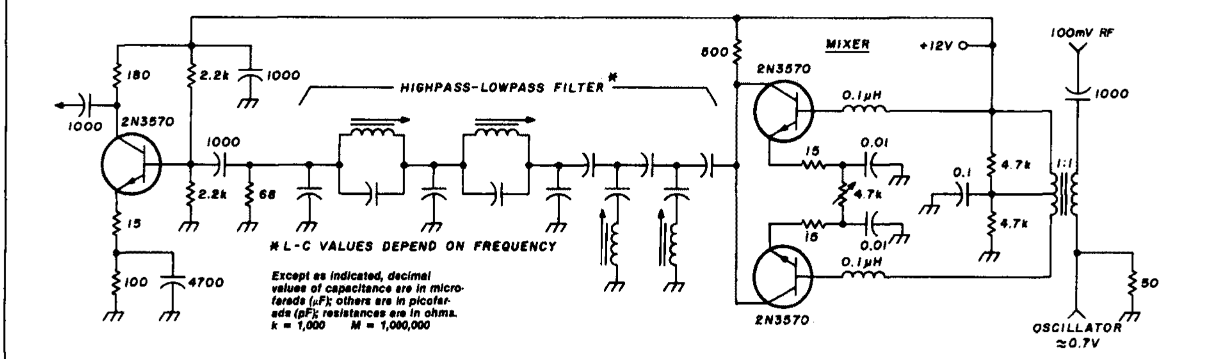


fig. 9. Active mixer with transistors and bandpass filter.

practical circuits

Because we are interested in the problems of balancing harmonics and other unwanted products, we will not consider simple, single-stage mixers but instead will look at several active mixer circuits that pretty much represent the state of the art. Depending on the bias to cutoff ratio of the devices selected, fairly high intercept points (up to +30 dBm) can be obtained.

Fig. 9 is the schematic of an active mixer using two VHF transistors in push-pull. Because of the number of spurious frequencies generated, substantial filtering at the output is recommended, as can be seen from the highpass-lowpass filter section. The two rf chokes at the base of each transistor prevent unwanted oscillation at fairly high frequencies.

Fig. 10 shows a balanced mixer using the 3N200 field-effect transistor in push-pull. This is a multiplicative mixer in which the rf input signal is fed in parallel.

Ed Oxner of Siliconix has designed several mixers based on the U257 transistor. The schematic is shown in **fig. 11**. Siliconix also made a version with four field-effect transistors in one package. **Fig.12** shows the schematic of such a configuration using the U350.

VMOS transistors have become popular, and a push-pull version with the **VMP4** power FET, as described by Doug DeMaw, was shown in *QST*.[4] (See **fig. 13**.)

Most loads into which the mixers operate do not present precisely 50 ohms to the mixer output. Also, most designers of active mixers have carefully avoided indicating the effects that occur in active mixers as the termination changes from a purely resistive 50-ohm load into some other value. In general, any change in resistive load that does not introduce reactive components does not affect the mixer substantially. A VSWR of 1:2 from 50 ohms, or change of load from 25 to 100 ohms resistive, does not have too many adverse effects. If, however, the mixer is terminated by an LC filter or crystal filter, the impedance changes and becomes reactive, and the intercept point changes drastically. In some cases with active mixers, I have observed instabilities even to the point where the mixer turned into a low frequency oscillator.

Three basic circuits are known to prevent change of impedance. **Fig. 14** shows a recommended ar-

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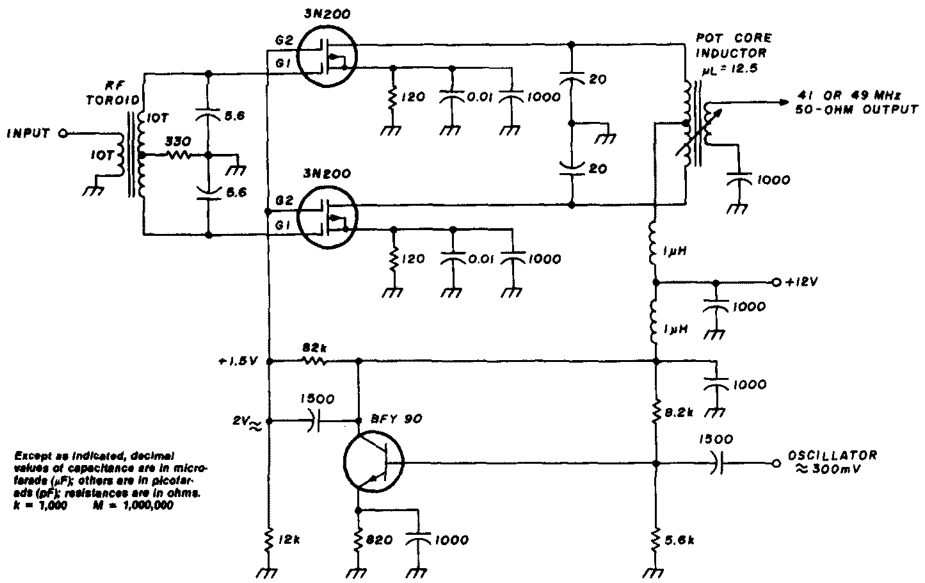

fig. 10. Push-pull mixer with 3N200 FETs.

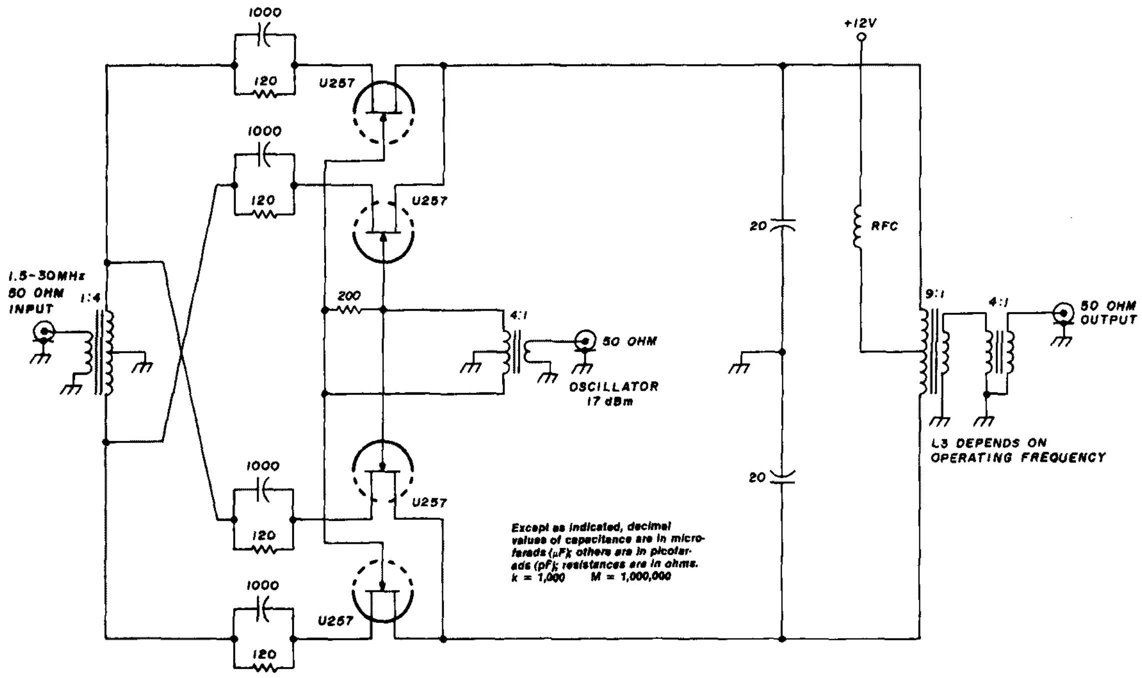

fig. 11. Double-balanced mixer with Siliconix U257.

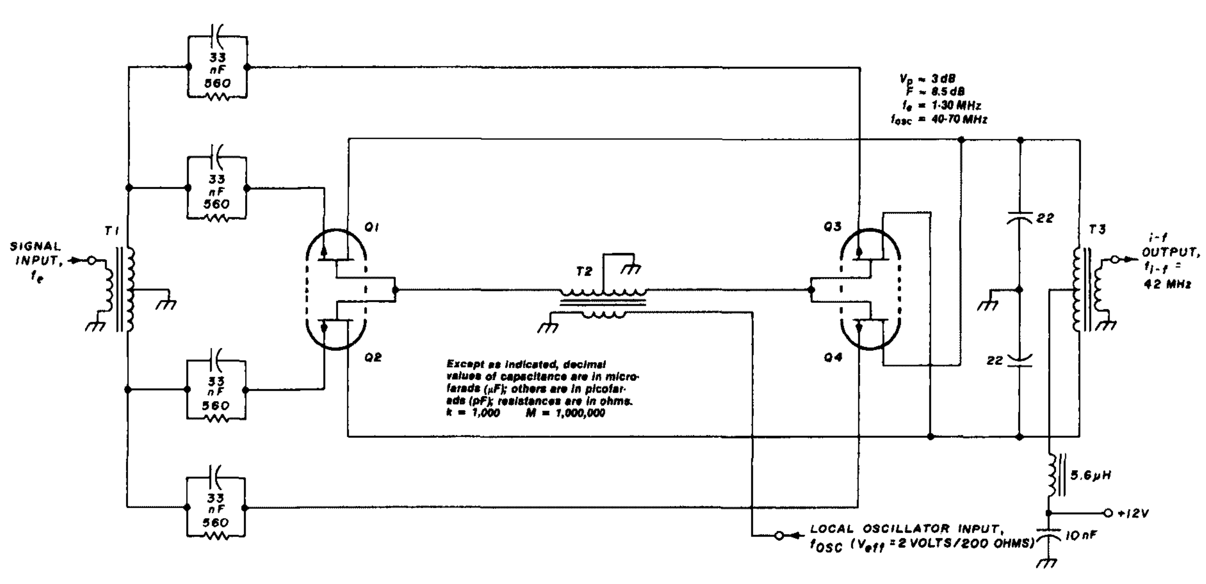

fig. 12. Double-balanced mixer using U350.

rangement whereby the mixer, in this case a passive double-balanced mixer, is terminated by the input impedance of a grounded-gate field-effect transistor. It must be remembered that grounded-gate field-effect transistors properly biased exhibit purely resistive input over an extremely wide frequency range.

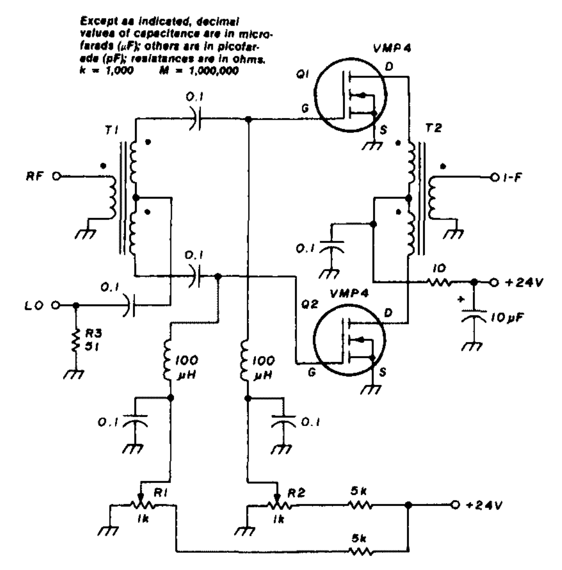

fig. 13. Push-pull mixer with VMP4 FETs. (Original circuit appeared in *QST*, January 1981, page 22.)

This holds true in most cases basically from dc to several hundred MHz. The CP643 or CP640 made by Teledyne Crystalonics is a good choice.

Another alternative is a feedback amplifier that uses noiseless feedback as described in the literature[5,6] based on patent 3891934 of 1975. The third alternative is the use of a diplexer whereby the image at the output of the mixer is terminated with a 50-ohm resistor.

Probably the best solution is a combination of two transistors with a diplexer as shown in **fig. 15**. Again, for convenience, the circuit is shown with a passive balanced mixer together with this particular termination circuit.

Let's now take a look at some systems calculations that will yield a surprising result.

Active mixer with perfect termination. Consider an active mixer such as the Plessey SL6440 in any of the previously shown schematics. The noise figure under large-signal operation is around 11 dB for the Plessey device and 8 dB for a U257 mixer. Relative to the typical loss of 6 dB in a passive mixer, the zero-dB gain of an active mixer already represents gain; to be specific, 6-dB gain over the passive device. Let us assume further that the amplifier following uses noiseless feedback and its noise figure is 2 dB. As the mixer has unity gain, the noise figure at the input is equal to the noise figure of the second stage plus the noise figure of the mixer, and in the case of the Plessey mixer the resulting noise is 11.2 dB.

If we use a U257 stage, we get a 10-dB noise figure if we allow the same amount of gain. The intercept point is determined by the mixer and the second amplifier, and because of the special rf feedback applied in the second amplifier, we will, for the moment, assume that the second amplifier does not contribute any intermodulation distortion products. The very moment we operate the mixer with gain, we must take distortion of the second stage into consideration.

Passive double-balanced mixer with termination stage. Let's use the same example with a high-performance double-balanced mixer. The double-balanced mixer has an insertion loss of 6 dB, and the noise figure also is 6 dB.

The noise figure of the termination stage again is 2 dB, which results in a total systems noise figure of 8 dB, or 2 dB better than the previous example with the U257. Because of the 6-dB losses of the double-balanced mixer, the intermodulation distortion of the double-balanced mixer can be neglected, and the designer can concentrate on the mixer itself. This, I am sure, is a surprising result for most design engineers.

It is important to understand that the termination stage, when using the noiseless-feedback system, must also operate into a stable load. Any changes of the output load of such an rf feedback amplifier will be reflected into the input. A recommended way to reduce this change is to operate this stage at a higher than necessary gain; 3 or 4 dB is sufficient. A resistive pad with 3-dB attenuation will then prevent dramatic changes at the output.

In the case of the grounded-gate field-effect transistor as a termination, this circuit works reliably only if the drain-to-source feedback capacitor is kept extremely small and the capacitance is basically determined by the transistor itself.

If the output stage must operate into a crystal filter, we will find that most crystal filters outside the passband characteristic exhibit high impedance, which is either inductive or capacitive. This effect can be reduced by using a highpass filter at the output that incorporates the crystal filter. If the crystal filter's impedance increases, the highpass filter is mistuned, and the voltage at the drain or collector remains low. As a result, the third-order intermodulation distortion products remain low. In a convenional circuit, it is sometimes found that the sudden increase of impedance at the output of the transistor makes the intermodulation distortion deteriorate.

passive mixer with active devices

Recent developmental work in the field of mixers

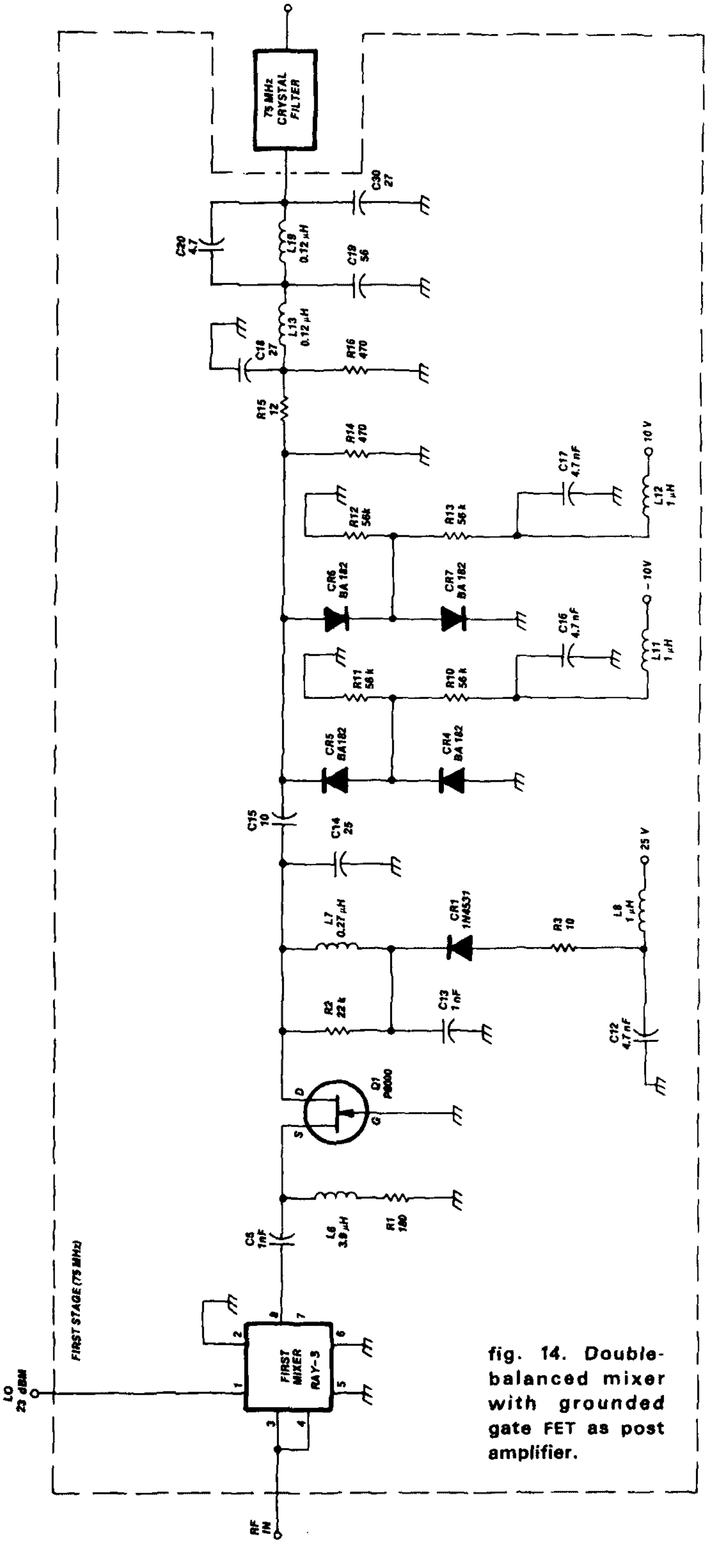

fig. 14. Double-balanced mixer with grounded gate FET as post amplifier.

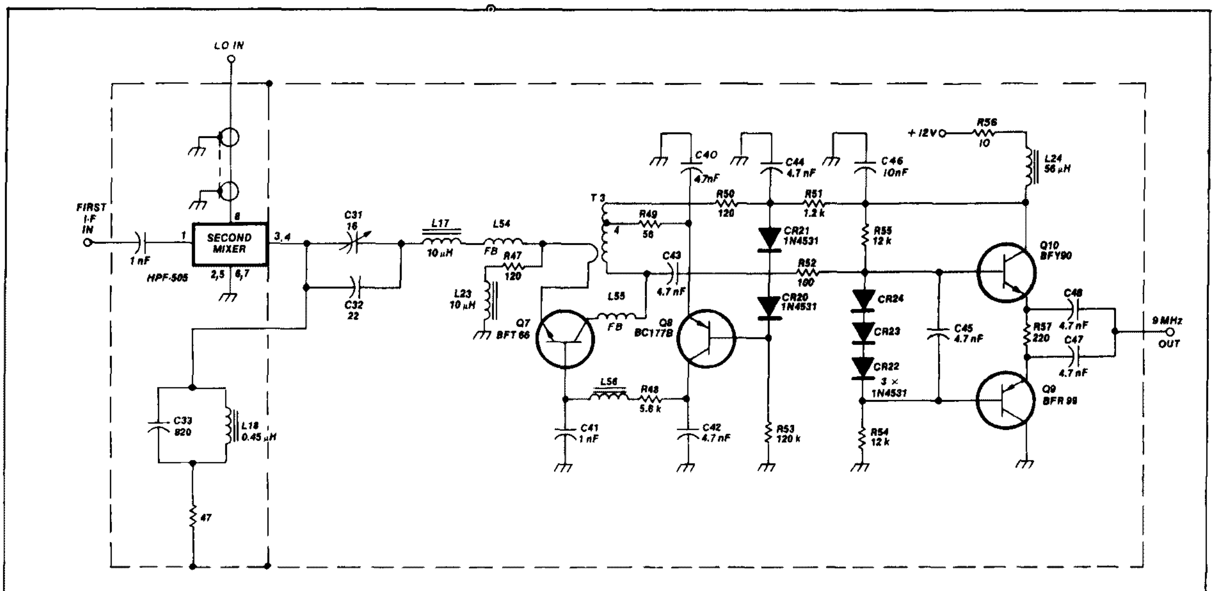

fig. 15. Double-balanced mixer with noiseless feedback amplifier as well as diplexer as termination.

indicates that the best way of achieving high intercept points in mixers is the use of:

1. Bipolar transistors as switches and with feedback.
2. Field-effect transistors as switches.

In ordinary applications, mixers using active devices operate on the nonlinear transfer characteristic, as explained earlier. Diode mixers are substantially better, because here the device is only switched on and off, and if the on-off resistance of the device has a high enough ratio, the device will be fast enough to follow the local-oscillator drive waveform. Enough local-oscillator drive power is available, theoretically, so that no harmonic distortion should occur. The losses would be 3 dB, as would the noise figure; thus we would not observe any intermodulation distortion products at all. Using active devices, we depend upon the nonlinearities of the input and output ports and, as with the field-effect transistor, possible distortion of the gate source diode and the potential nonlinearities of the channel resistance.

The state of the art for mixers using field-effect transistors without operating voltage and, therefore, only as switches, indicates approximately a +42 dBm input intercept point, 5.5 dB noise figure and insertion loss, and local-oscillator requirements of about +23 dBm. The local-oscillator drive requirement really results from the fact that a certain voltage has to be available at the gate electrode. In a quad configuration, this voltage can be as high as 50-volts PEP into the input capacitance of the transistor. The step-up transformer helps reduce the required power.

Fig. 16 shows the schematic of such a recomended mixer which, for test purposes, has a tuned input. This circuit is based on a patent issued to Mr. William Squires in 1968, number 3383601. It can be reported that for 1-volt input signal or +13 dBm, the third-order intermodulation distortion products are at −83 dBm, or 100 dBm down. This would increase to an intercept point of +70 dBm but can only be achieved in a narrowband circuit. In a wideband configuration, only 40 to 42 dBm is obtainable. The isolation between oscillator and signal port is about 60 dB and provides about 40-dB isolation to the i-f signal.

The area of using passive mixers with active devices is fairly new. The only company that seems to have a commercial product is Lorch in New Jersey, and the latest prices I have seen for their mixer were $600 or $700.

I had built an active mixer based on feedback and switching, which was published in *ham radio*.[7] This mixer with similar performance was used in the Rhode & Schwarz 400-watt transceiver in the Tornado warplane.

testing

To make proper tests on the mixers using signal generators, a hybrid coupler with at least 40 dB isolation between the two input ports and an attenuator are required. The test setup provided by DeMaw in *QST*[4] and shown in **fig. 17** is ideal for this. He used

two signal generators with outputs around 14 MHz and combined them. An attenuator drives the mixer under test (MUT), the local-oscillator signal is supplied by a VFO, and the output is then analyzed.

The 2N5109 amplifier shown may not be sufficient for extremely high intercept points, as this stage may no longer be transparent. For stability tests when using active mixers, it is recomended one have a reactive network at the output of the mixer for the sole purpose of checking mixer instability.

Rather than use expensive signal generators, two oscillators with extremely low harmonic content and

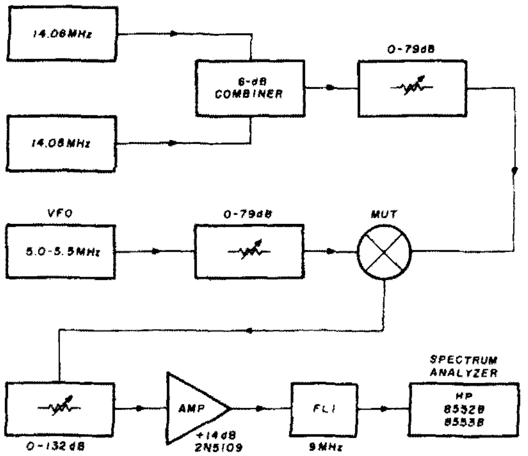

fig. 17. Recommended test setup for measuring mixer intermodulation distortion. (Original circuit appeared in *QST*, January, 1981, page 20.)

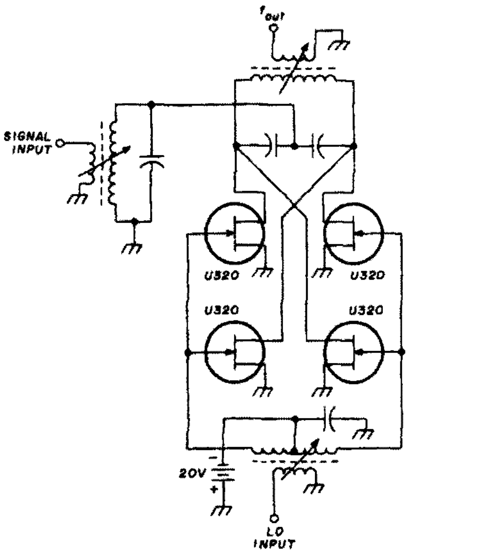

fig. 16. Schematic of a passive double-balanced mixer using FETs in a quad arrangement. This circuit represents the state-of-the-art that is possible today. While the narrowband version can have input intercept points of +70 dBm, a wideband version achieves about +42 dBm.

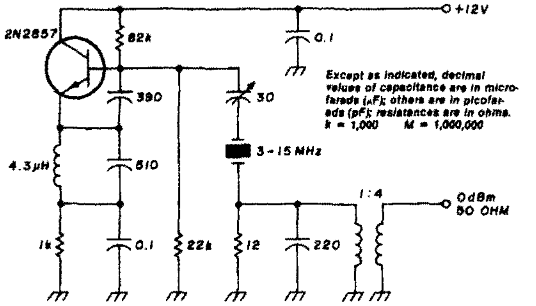

fig. 18. Low-noise crystal oscillator with 60-dB harmonic suppression.

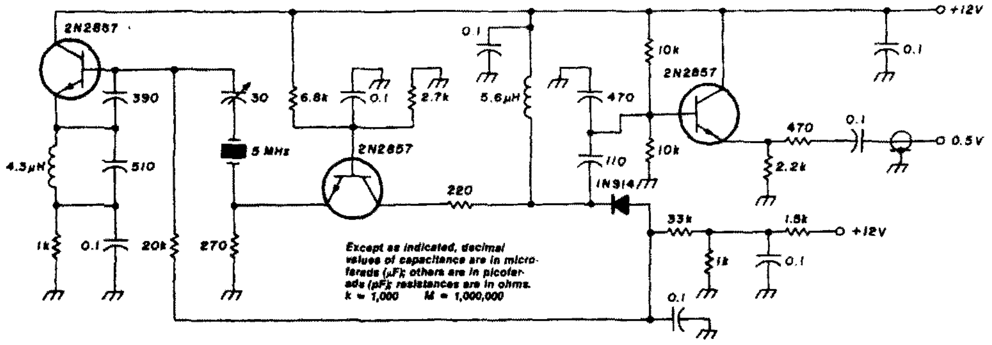

fig. 19. Ultra-low-noise crystal oscillator with ultimate noise floor of 168 dB/Hz.

very low noise sideband performance can be used. A convenient circuit to provide the required harmonic suppression and low noise is shown in **fig. 18**, based on an earlier paper of mine.[8] For those interested in obtaining an additional 20-dB improvement in noise sidebands and need a test oscillator with this performance, the circuit in **fig. 19** is recommended. This oscillator shows an ultimate noise floor of 168 dB/Hz at 1 kHz off the carrier. As can be seen, this oscillator is a derivative of the earlier one. The input impedance of the grounded-base stage is about 2 ohms and, therefore, does not really deteriorate the Q of the crystal.

summary

I have explained that ordinary active mixers based on the inherent nonlinearities of their transfer characteristic by definition will show a lower intercept point than is possible with passive devices. Passive devices are already used with great success, and the termination-insensitive mixers, although they are not yet offered below 1 MHz, are currently the state of the art in diode mixers. By using feedback techniques together with switching-type active stages and bipolar transistors (or better yet, using modern power junction field-effect transistors), I have measured third-order and higher input intercept points to 40 dBm. In selective cases and narrowband frequency operation, +70 dBm intercepts have been reported. It is not likely that these figures will be useful, as the termination stages of following crystal filters or other devices will become the limiting factor.

I have just learned that Mini-Circuit Laboratories has introduced a new mixer, type VAY1, that claims a 38-dB intercept point at the input, which results in a 32-dBm intercept point at the output. However, the drive requirements are much higher than for the passive FET mixer.

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ham radio

words-per-minute readout for the deluxe memory keyer

After having constructed several "Accu-Keyers,"[1] and the "Deluxe Memory Keyer,"[2] I found that the one thing missing in both was the ability to tell exactly how fast I was sending. I thought there must be a simple way to add this convenience to these superb keyers. Most of the hardware to accomplish this is already mounted in the keyers: the clock pulses, counters, and the drivers with the readouts. The only missing part for the frequency counter are the timing gates, a time base and the readout latches.

words per minute versus frequency

The handbook states that 24 WPM equals 10 dots per second times 2.4. To put it in another way, 24 WPM equals 24 dots per 2.4 seconds. It takes two clock pulses to equal one dot (1 dit and 1 space), so 24 WPM equals 48 clock bits per 2.4 seconds, or 24 clock bits in 1.2 seconds. All we have to do now is to let the counters tally the clock bits for 1.2 seconds, put in two 7475 latches to hold this count and display it on the readouts, and we have our WPM counter. On my first attempt at building a speed readout, I used a 3.58-MHz TV crystal and a 5369 oscillator chip for the 60-Hz time base and a multipole rotary switch to change modes. But then I decided a less expensive approach would be to use the 60 Hz from the secondary of the power transformer and two more 7400 chips to do the switching instead of the more expensive rotary switch. Thus evolved the circuit described here.

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theory of operation

Refer to **fig.1**. In the WPM mode, the DPDT switch

View of the speed adapter board mounted on top of the driver board. The existing keyer memory board is under the driver board. The bit count, WPM mode switch is mounted in the upper left corner, rear, next to the speaker. ***(Photo courtesy of Bill Mansfield, W1MLT.)***

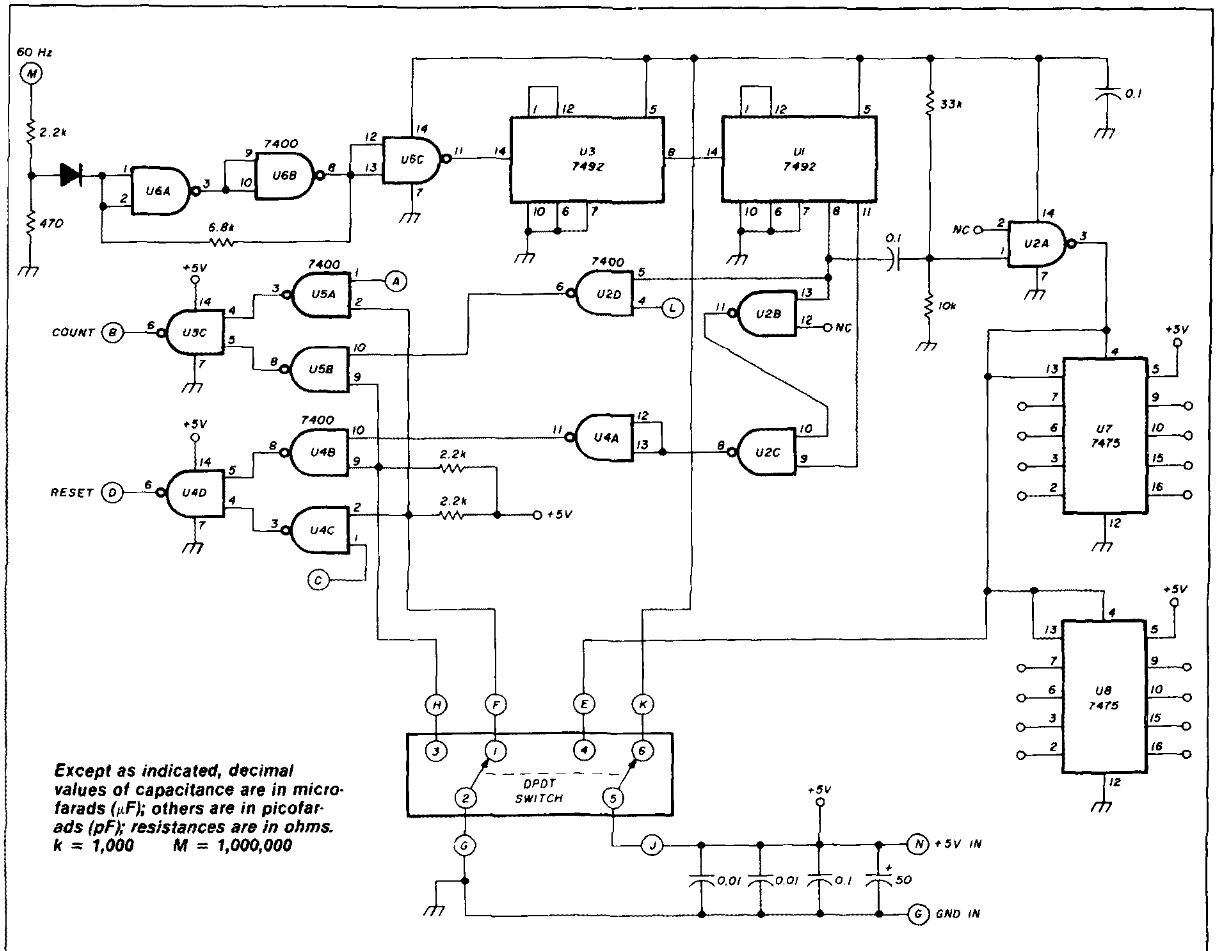


fig. 1. Schematic diagram of the WPM readout adapter. The circles indicate wire connections.

turns on the 5-volt supply for IC U1, U2, U3, and U6. The switch also grounds pin 2 of U4C and U5A, blocking out the count and reset pulses from the memory chip. Sixty Hz is fed into U6 from the power-transformer secondary. The 60-Hz waveform is shaped and conditioned by U6 and is fed into U3 (divide by 12). The output of U3, pin 8 (5 Hz) is fed into a second divide-by-12 IC, U1. The output of pin 8 of U1 is 2400 milliseconds, or 2.4 seconds long. This pulse is fed to pin 5 of the U2D NAND gate, which is high for 1.2 seconds and low for 1.2 seconds. During the high on U2D pin 5, the gate is held open, which allows the clock input pulse on pin 4 to pass through for a 1.2-second period. This count is in words per minute; that is WPM equals the number of clock pulses per 1.2 seconds. When pin 8, U1 goes low after the count time is concluded, pin 1 of U2A is pulsed, causing a high strobe pulse at its output and at pins 4 and 13 of U7 and U8. This action momentarily opens the 7475s, which latch onto the count and display it through the readouts. A pulse at pin 9, U2C resets the counters to zero and a new count begins.

In the **NORMAL** mode of operation, pins 9 of U4B and U5B are grounded, blocking the WPM counter and reset pulses, which allows the normal memory bit count and reset pulses to pass through to the counters. The other half of the DPDT switch removes the 5 volts from U1, U2, U3, and U6. This disables them and places 5 volts on the 7475 latches, holding them open to allow a steady bit count to be displayed.

construction

The speed adapter board uses eight inexpensive ICs, about $3 worth. The whole project shouldn't cost over $10 if all the parts have to be purchased

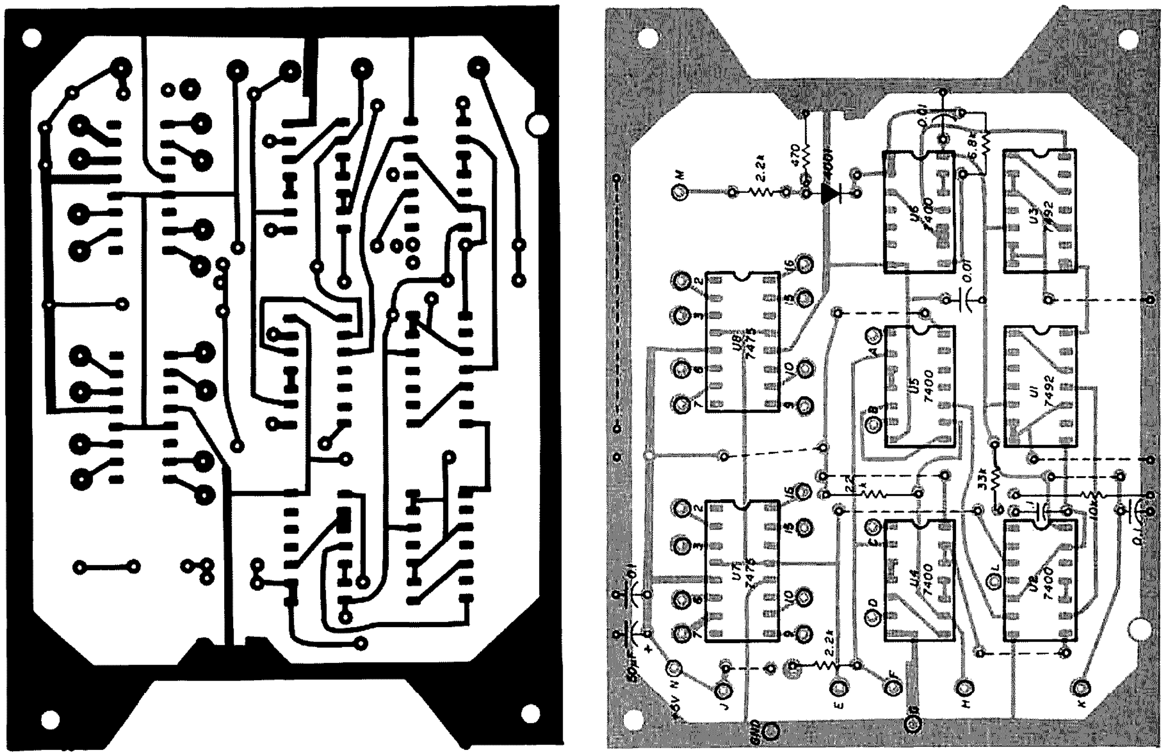


fig. 2. Foil side, *A*, and component side, *B*, of the speed adapter board. Dotted lines are wire jumpers.

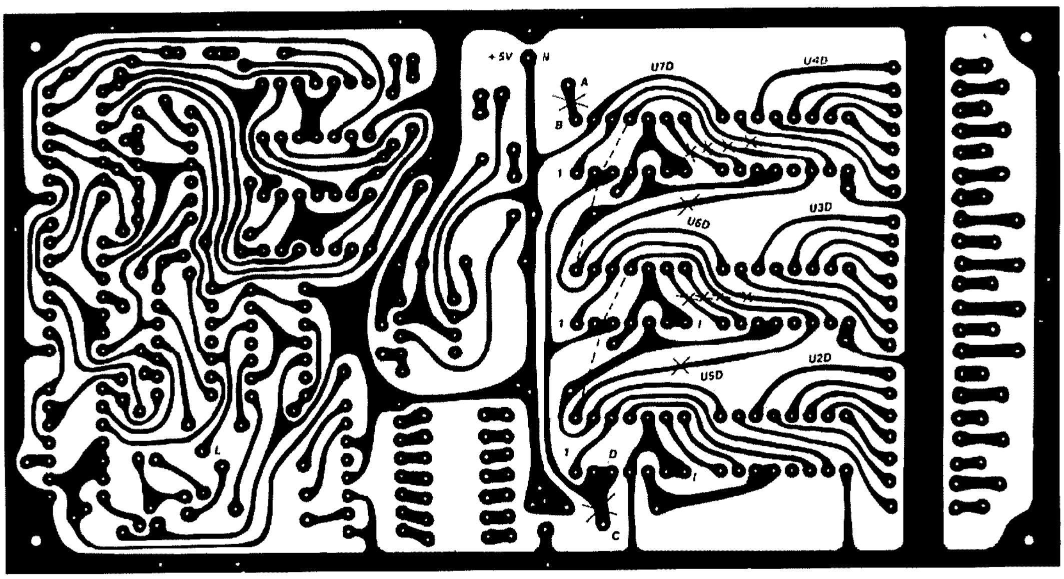


fig. 3. Foil side of Deluxe Memory Keyer driver board. Cut foil at 12 points marked with *X*. Connect wires from speed adapter board to identical letters on driver board. Add two jumper wires as indicated by dotted lines.

new. Components are mounted on the non-foil side of the board, as shown in **fig. 2**. All resistors can be ¼ watt. Capacitors are disc, except the 50 μF, which can be either electrolytic or tantalum at 10 volts. Dotted lines indicate jumper wires. Be sure the ICs are oriented correctly. I used sockets for the ICs, which makes them easier to change in case I zap one. Care must be taken when soldering in the sockets to prevent solder bridges across the pins. (I can supply a limited number of drilled and etched circuit boards for $6 each.)

The hookup requires 30 wires, so ribbon cable is the best route to follow. The jumper wire along the edge of the board in **fig. 2** is used to anchor the ribbon cable to the board. Mount the cable here first and leave about 5 inches (13 cm) for a hookup, then peel back each wire to the jumper anchor before routing to the designated letter. Measure and route each wire separately to its terminal. Cut, insert and solder each wire by number as shown in table 1 to avoid a mixup.

driver board

To prepare the driver board, the foil must be cut in twelve places as shown in **fig. 3**. Also add two jumper wires as shown by the dotted lines, from pin 11 of U7D to pin 14 of U6D, and from pin 11 of U6D to pin 14 of U5D.

wiring the driver board

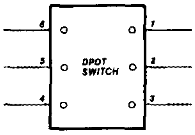
The ribbon cable can now be installed on the driver board. Leave about 1½ inches (4 cm) of the cable between the boards for a hinge, and anchor the ribbon on the foil side of the driver board with a jumper wire across it. Leave about 7 inches (18 cm) of the ribbon on the free end. Peel back the first twenty-four wires to the anchor point. The last six wires may stay together. Run the last six wires to the DPDT switch and solder them on as indicated in **table 1**. All the connections to the driver board will be made on the foil side. Tack each of the first sixteen wires to the IC pin numbers as indicated in **table 1**. The next six wires go to the indicated letters. The twenty-third wire goes to either side of the secondary of the power transformer. The twenty-fourth wire is soldered to point **L**, in the keyer section of the driver board. The speed adapter board is mounted directly over the driver board with spacers in between.

operation

With the switch in the WPM position, a string of dots about 3 seconds long will give an exact WPM count on the readout. Set the speed control to the speed at which you would like to send. The readout will receive a count update every 2.4 seconds. Any hesitations during sending will show a corresponding slower speed on the readout. With the switch in the normal position the keyer will operate as it did before the adapter board was installed. The bit count from or to the memories will be displayed on the readout.

table 1. Wire connections for 30 wire ribbon cable from speed adapter board to driver board and to DPDT mode switch.

wire no.	from driver board: device	pin no.	to adapter board: device	pin no.
1	U3D (7447)	7	U8 (7475)	9
2		6		15
3		2		16
4		1		10
5	U4D (7447)	7	U7 (7475)	9
6		6		15
7		2		16
8		1		10
9	U6D (7490)	8	U8 (7475)	2
10		9		6
11		11		3
12		12		7
13	U7D (7490)	8	U7 (7475)	2
14		9		6
15		11		3
16		12		7
17	reset C		reset C	
18	reset D		reset D	
19	bit count A		bit count	A
20	bit count B		bit count	B
21	ground		ground	G
22	+5 volts		+5 volts	N
23	ac secondary transformer		ac in	M
24	U4-7474 Cl pulse		Cl pulse	L
	pin no. on switch		**letter on adapter board**	
25	3		to	H
26	2		to	G
27	1		to	F
28	6		to	K
29	5		to	J
30	4		to	E



Two jumper wires on driver board

wire pin 14, U6D	to	pin 11, U7D
wire pin 14, U5D	to	pin 11, U6D

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ham radio

operation upgrade: part 6

The sixth part in a continuing series designed to help you upgrade your ticket

This series of **articles** is being presented to help you pass a higher grade Amateur license exam, to give you the basic radio theory needed to pass a Novice, *Technician/General, or Advanced class* license test. After these basics are presented in as simple a form as possible, there will be articles covering Extra class license subjects.

This month we will examine the three basic forms in which active devices can be connected in amplifier circuits. Also, feedback and decibels will be outlined briefly.

classes of amplifiers

When active devices are used *in* amplifying circuits, the portion of the time that current flows in them determines the class of operation. The class of operation also helps to determine the efficiency of the amplifying stage. The three basic classes of operation are class A, class B, and class C. Most amplifiers are operated in class A, so we will discuss this class first.

Class A operation is the least efficient, but also distorts the amplified signal the least. Let's consider the solid-line curve of **fig.** 1 first. Represented vertically, at the left, is the output circuit current (drain, collector, plate). Represented horizontally is negative, zero, and positive bias voltage for N-channel FETs or for VTs (vacuum tubes). You will note that the class A bias value is about halfway between output current cutoff and zero bias (or output current maximum). The shaded area illustrates the output-circuit current variations that occur with both a small input ac signal (e_i), and then a higher amplitude input signal. If the large input signal were made much greater it would drive the device into output current cutoff, or into the bent part of the curve at the top, or both.

Under the maximum undistorted output signal condition shown, the efficiency of the amplifier stage (its ac power output compared with its output circuit dc power input) would be about 45 percent (the theoretical maximum is 50 percent). With a small input signal, the dc power input to the output circuit averages the same but the ac power output will be much less because the output dc current varies less. In this case the efficiency of the stage might be only 5 or 10 percent. Normally, the efficiency of an operating class A audio amplifier averages about 25 percent. Class A operation has the advantage of requiring only a *single* active device to *produce* relatively undistorted amplification. This class of amplifier can be used for both audio and radio frequency amplification when distortion must be kept to a minimum.

Can you see that if the operating curve of the active device used happened to be curved or nonlinear (which it usually is), as is shown dashed, that even if

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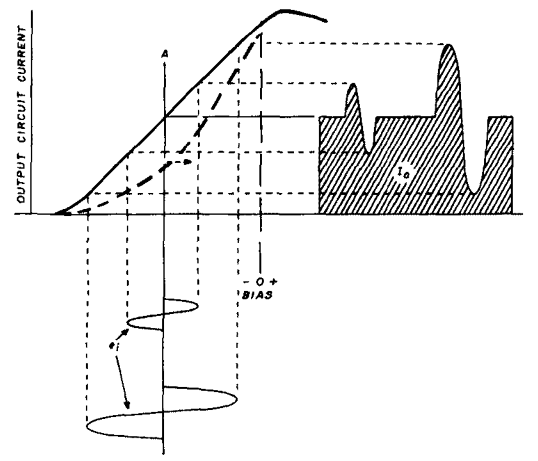


fig. 1. Operational curve to indicate how output circuit current I_o varies with input signal voltages e_i for a class A amplifier (simplified).

the input signal voltage had equal positive and negative peaks, the output circuit dc variations would be smaller for the negative half cycle of input ac, and larger for the positive half? This would produce a noticeably distorted output audio signal from such a stage. It would produce harmonics of all frequencies it amplified.

Class B operation is more efficient than class A but usually distorts more than class A; it requires two *push-pull* devices (first one operates and then the other) in a single stage for audio amplification. In the two-stage amplifier shown in fig. **2**a the first stage is a JFET class A *single-ended* af amplifier (one device used and one end of its load grounded or bypassed to ground) which is transformer-coupled to a push-pull class A or B power amplifier second stage, transformer-coupled to a loudspeaker. Whether the output stage is biased to class A or B is determined by the values of bias developed by R_1 and R_2. The curve shown in fig. **2**b indicates that with no bias at all on the BJT (R_1 = *zero ohms*) there is no collector current with no input signal. The bases of the two NPN transistors must be forward biased a little to produce class B operation ($R_1 = \pm 5$ *ohms*). The BJT bases must be forward biased considerably more to put them in class A (dashed line). With class B bias, only the positive half of the input signal produces I_C in the transistor whose curve is shown.

Assume this curve is for the top BJT. Then during the next half cycle of the input signal, the top BJT will nave no I_C flowing, but the lower BJT is now being driven by the second half of the input ac signal. The voltages at the top and bottom of the center-tapped input transformer secondary will be 180° out of phase with each other. As the top BJT is being fed the signal as a negative (reverse) voltage, the lower BJT is being fed the same signal but as a positive (forward) voltage, and the lower BJT now has I_C flowing in it. In this way the output transformer primary has current flowing first in its top half and then in its bottom half. Both primary currents induce voltages into the secondary to feed power to the loudspeaker. Can you see that each BJT is working only about half of the time? For example, during much of the second half cycle of the input signal, the top BJT rests (cools). As a result, a pair of class B biased active devices will produce much more power output than two parallel-connected (B to B, E to E, and C to C) class A devices, both of which would have current flowing in them at all times. Practical class B stages can operate with maximum efficiencies in the range of 55 percent. If a single BJT in class A is capable of 1 watt output, two connected in parallel would be capable of 2 watts output, but two in push-pull could be driven to produce about 8 watts output if in class B, partly because of their ability to rest almost half of the time, plus the fact that a greater input signal could be accommodated with class B bias. When producing power output all active devices must have effective heatsinks attached to their collectors, drains, or plates.

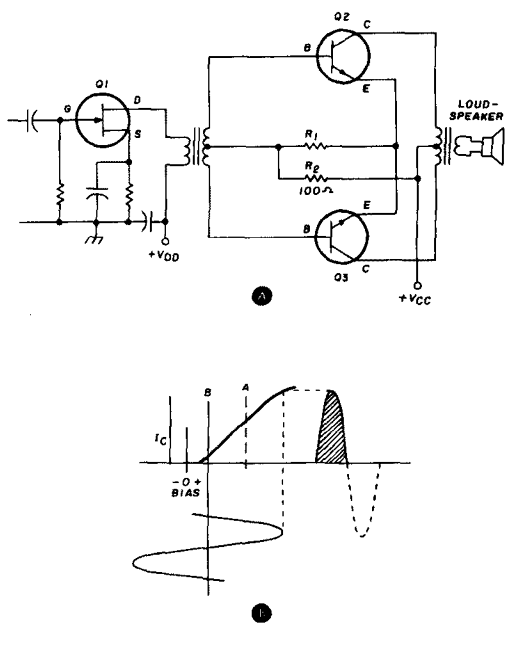


fig. 2. (A) Two-stage push-pull output af amplifier. (B) I_C versus input voltage (current) operation curve.

It should be mentioned that you will normally find BJT curves plotting emitter-collector voltage versus collector current with a series of more or less parallel horizontal lines indicating various base (input circuit) current values.

Class AB operation means biasing to some point between class A and class B. For audio amplifiers this also requires that two push-pull devices be used. As you might expect, class AB is in between classes A and B as far as power output and distortion are concerned. When using push-pull class A and class AB there is one other advantage. The two devices are operating 180° out of phase with each other so that any bend in the operating curves, which normally produces distortion in the output of a single ended stage, will be cancelled by the reversed curve (effectively) of the other device. This results in nearly distortion-free amplification in such push-pull stages. When using vacuum tubes (and N-channel FETs) class AB_1 indicates the input signal should never be

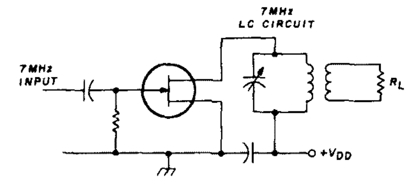


fig. 3. Basic class C rf amplifier (or frequency doubler if the input frequency is 3.5 MHz).

great enough to drive up into the positive bias area and produce grid (gate) current. Class AB_2 operation implies some grid current and that the input circuit resistance (impedance) is engineered low enough so that when the signal does drive into an input current condition, there will be no unwanted voltage drops developed across any resistance in the input circuits to produce distortion.

Class C operation is not used with audio amplification, but usually only in transmitter rf amplifiers or in oscillators. Class C stages are normally biased from 1.5 to perhaps four times the cutoff, or pinchoff, bias value. (Technically, a BJT with zero bias is in class C.) As a result, for a major proportion of the 360° of any input cycle (perhaps 240°) the device has no output circuit current; it's resting. It can produce maximum output power at perhaps 65 percent efficiency. This means that the output circuit current comes in relatively narrow (120°), high-amplitude pulses. If these powerful pulses are forced through an output LC circuit tuned to some radio frequency, such as 7 MHz (as in **fig. 3**), the pulses shock-excite the LC circuit into flywheel oscillation and produce nearly sinusoidal 7-MHz rf ac output from it. Of course, the input rf ac to such a class C amplifier should also be at 7 MHz, although if it is at 3.5 MHz the circuit will operate as an rf *frequency doubler*. Since class C amplifiers depend on the flywheel effect of relatively high-Q LC circuits to produce the output ac, the stages may use either single-ended one-device circuits, or may use push-pull circuits. Push-pull rf ac circuits produce less even-order (second, fourth, sixth, and so forth) harmonic ac output, and may be desirable to suppress such frequencies. If the coupling to a load on a single-ended class C rf amplifier (R_L in **fig. 3**) is too tight it will lower the Q of the LC circuit involved and drain the flywheel energy on the *undriven* half cycle too much. This will reduce the amplitude of the second flywheel half cycle and distort the sinewave shape of the ac wave. This develops harmonics and unwanted radiations. Push-pull stages do not have this difficulty as much as single-ended stages.

common-emitter type amplifiers

There are three basic methods of connecting and feeding three-element amplification devices such as FETs, BJTs, and VTs. Let's examine the basic theory as it applies to bipolar junction transistors. The most common amplifier circuit configuration is that of the common-emitter (common-source for FETs, common-cathode for VTs), also known as the grounded-emitter (-source, -cathode). The circuit shown in **fig. 4** illustrates a single-ended NPN BJT class A amplifier. R_1 and R_2 provide the forward bias for the transistor. R_3 produces the stabilizing bias to keep the transistor from thermal runaway in power stages. R_L is selected to produce a voltage-drop across itself with no signal input, of perhaps one third to a half of the V_{CC} value (depending on the R_3 value). R_L will probably be in the 1 to 5 kilohm range, depending on the beta of the transistor, the bias value, and the V_{CC} value. For af amplification the input and output coupling capaci-

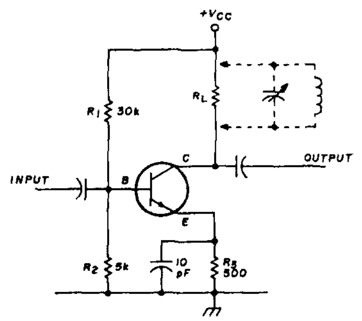


fig. 4. Common-emitter or grounded emitter form of BJT amplifier.

tances would be in the 5 to 15 μF range. The lower the lowest frequency to be amplified, the larger the capacitance values required. For high-frequency rf amplification the capacitors might be in the 0.01 to 0.1 μF range, but such an untuned rf amplifier is not often used. In rf amplifiers the R_L would usually be supplanted by a tuned LC circuit, shown dashed.

Generally, regardless of the V_{CC} value, the load resistor and bias values are selected so that with no signal input the voltage-drop across R_L will be equal to the EC voltage-drop for good class A operation.

Common-emitter-type circuits represent a relatively low impedance load for the stages ahead of them, perhaps 50 to 200 ohms, and look like a medium impedance to the stages that follow. With FETs, **fig. 5**, the common-source circuit usually uses a resistor between source and ground to provide bias. The input impedance of this stage in class A operation is essentially as high as the resistance of the gate-to-ground

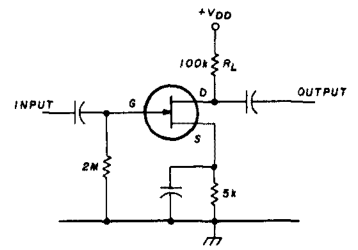


fig. 5. Common-source or grounded-source type amplifier.

resistor used in it. The output circuit impedance is perhaps one half of the resistance of the drain load resistor, R_L. If using tuned LC circuits for rf amplification, the output impedance may be several hundred to several thousand ohms. Vacuum tubes are similar to the FETs in impedance and component values. The phase shift of a signal amplified by all of these common-emitter type circuits is usually considered to be 180°.

common-base type amplifiers

A common-base, or grounded-base (-gate, -grid) amplifier is shown in **fig. 6**. R_1 and R_2 form a voltage divider across the power supply ($+V_{CC}$ to ground). Since the base is connected up the voltage divider from ground it is more positive than the emitter, which returns to ground through the input resistor. The amount of forward bias required to produce class A operation is that which will produce a static (no signal) I_C value somewhat less than half the maximum rated I_C value. C_1 is a filter capacitor whose

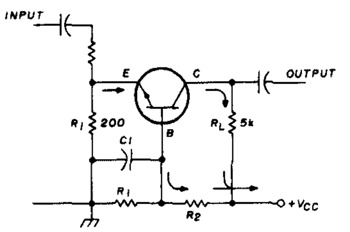


fig. 6. Common-base or grounded-base type amplifier.

function is to prevent any signal voltage variations from developing across R_1 as the input signal forces the I_B to change at the signal frequency and amplitude. Input-signal currents through the 200-ohm input resistor develop varying voltage-drops across it. Since these varying voltages are between base and emitter they force the collector current to vary, producing an amplified voltage-drop variation across the relatively high resistance load resistor. Can you see that the emitter current is the sum of both base and collector currents (arrows)? Therefore, the ratio of I_C to I_E will always have to be something less than 1, usually in the range of 0.95 to 0.98. This ratio or value is known as the ***alpha*** (α) of the transistor. The ***alpha cutoff frequency*** is the frequency where the gain of the transistor drops to 0.707 of its gain at 1 kHz.

Although a common-base circuit cannot have a current gain, it can have a voltage gain and therefore a power gain. If the signal voltage applied to the 200-ohm resistor is going positive, the base, being held constant by C_1, can be considered to be going relatively less positive than the emitter. We can say the base or control element is going relatively more negative. Such a reverse bias to the base reduces the I_C and the voltage drop across R_L decreases. This allows the top of R_L to become more nearly the $+V_{CC}$ value, or more positive. Therefore, as the input goes more positive so does the output, representing a phase shift of zero. With 0° phase shift there is little likelihood that this circuit will become regenerative and produce oscillations on its own. This is one of the advantages of such circuits. We say they are inherently stable, meaning that they are not likely to break into unwanted oscillations. When using vacuum tubes and an LC circuit in place of R_L, the equivalent circuit is known as a grounded-grid amplifier and is used in many of the present-day high-power Amateur rf linear amplifiers.

common-collector-type amplifiers

The third basic form of amplifier circuitry is the

common-collector, or grounded-collector (-drain, -plate) circuit, **fig. 7**. At first glance it may look like a common-emitter circuit, until you note that there is no load resistor in the collector circuit. Instead, the load resistor, R_L, is also the emitter resistor, R_E. Note that the collector is held at ac-ground potential by the relatively large value bypass capacitor, C_{bp}. An input signal applied base-to-ground causes I_C and I_E variations, which in turn produce variations of the voltage drop across R_E. The output voltage variation across R_E will always be a little less than the input voltage being fed to the base. However, this circuit has both current gain and power gain. Because a positive going signal to the gate produces an increase in I_C and therefore a more positive emitter, the common-base circuit produces zero phase shift of the amplified signal current. With 0° phase shift the circuit produces no regeneration and cannot break into oscillation, even at high frequencies. It is used mostly as an impedance-changing circuit. The input impedance is usually about half the value of R_i. With a high value of R_i the grounded-collector circuit acts as an impedance reducer, somewhat like a step-down transformer, except that a transformer cannot produce any power gain. This circuit is also known as an emitter-follower (source-follower, cathode-follower).

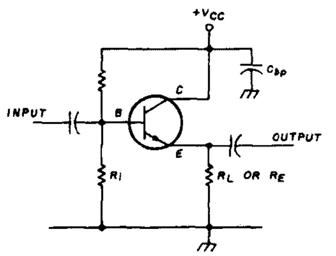


fig. 7. Common-collector or grounded-collector amplifier, also known as an emitter-follower circuit.

feedback

The term *feedback* deserves a little more explaining, since there is some of it in most circuits in which amplification occurs. The term itself indicates that a signal voltage (or current) being fed into an amplifier stage is amplified, and then part of the amplified output voltage (or current) is fed back into the input circuit. Assuming no time difference (phase shift) between the input signal voltage and the output, if the ac feedback voltage is out of phase 180°, or degenerative, the net result is a lessened effective input signal voltage, and therefore a lessened total gain of the stage. If there had been any distortion of the signal voltage (any change in the signal's waveshape) produced by the amplifying process of this particular stage (due to nonlinearity of its operating curve, for example) this distortion is also fed back 180° out of phase. This can almost completely cancel out any such distortion produced by the stage. Of course, if the input signal voltage were distorted to begin with, the degenerative feedback could not correct that. Degenerative, or *inverse*, feedback is used in many linear af amplifier systems, and may be developed as a degenerative loop feeding back distortion-cancelling voltages from a third stage back to a first stage, for instance.

The actual gain of a stage with inverse feedback can be determined by the formula

$$A_f = \frac{A}{1 + (-\beta)A}$$

where A_f is the amplification or voltage gain with feedback, A is the amplification without feedback, and $-\beta$ is a decimal fraction of output voltage (or current) fed back to the input. As an example, an amplifier without feedback has a gain of 20. What is its gain if the feedback factor is 5 percent (5 percent = 0.05)? Try working out this problem. Your answer should be an undistorted gain of only 10. With such inverse feedback, signal gain may be reduced, but when undistorted output is paramount this loss can be made up by merely adding another stage with inverse feedback. Furthermore, without feedback the gain of an amplifier stage might drop to a 50 percent output voltage at some lower frequency (due to the R and C values used in it). With the 5 percent feedback, at the original half-voltage frequency the output will now drop only about 10 percent. Thus, inverse feedback widens the bandwidth (spread of frequencies amplified almost equally) of an amplifier. In addition, instead of developing a 45° phase shift at the original half-voltage frequency, the resultant phase shift will be reduced to about 27°. So inverse feedback also reduces any undesirable phase shift (another form of distortion) in an amplifier.

If the feedback is close to 0° it has the tendency to make the stage around which it is introduced increase its gain (particularly at one frequency) if the feedback percentage is small. If such a forward or regenerative feedback is increased, it will usually cause the gain to rise so much at the frequency at which the greatest gain is being produced that the stage will break into oscillation at this frequency. As you may have deduced, both positive (regenerative) and negative (degenerative or inverse) feedback can be either an advantage or a disadvantage in electronic circuits.

decibels

You have probably noted that all of the amplifier

circuits have power gains, although the common-collector has no voltage gain, and the common-base has no current gain. We often talk about amplifier gain in terms of *bels* (after Alexander Graham Bell), or more commonly in tenths of bels (deci = 1/10), called *decibels*, or dB. Basically, a 3 dB gain means an approximately two-times output-over-input power gain. Another 3 dB, or a total of 6 dB gain represents an output of approximately twice plus twice more, or a four times gain. A gain of 10 dB is a power gain of exactly ten times. Thus, if an amplifier has 10 dB gain it amplifies the power fed to its input ten times. (We are speaking of power amplifiers here, not the usual class A FET or VT voltage amplifier which has essentially no power input but may have considerable power output.) If a power amplifier has 13 dB gain, it amplifies ten times (10 dB) plus 3 dB more, or twice ten, for a gain of twenty times the input power. What would be the power gain of an amplifier that has 16 dB gain? Can you see that the output would be ten times, plus being doubled again, then doubled again (10 dB + 3 dB + 3 dB), for a total gain of forty times the input power?

Since power is proportional to either the E^2 or the I^2 (from $P = E^2/R$, and $P = I^2R$), the voltage gain of an amplifier (assuming input and output impedances to be equal) in dB will be the square root of the power gain. A power gain of 6 dB is the equivalent of a four times power gain. The square root of 4 is 2. Therefore, 6 dB is the equivalent of a voltage (or current) gain of two times. If receivers have signal-strength-indicating meters (S-meters) and each S-unit is calibrated to be 6 dB greater than the one lower, one S-unit is equivalent to doubling (or halving) the signal voltage applied to the input of the receiver.

For accurate computations of decibels the formula to use is:

$$dB = 10 \log \frac{P_1}{P_2} \qquad \left(\text{from } B = \log \frac{P_1}{P_2}\right)$$

where P_1 is the larger power value being considered.

Variations of this formula to determine dB gain or loss using voltage or current values, again assuming input and output impedances to be equal, are:

$$dB = 20 \log \frac{E_1}{E_2}$$

$$dB = 20 \log \frac{I_1}{I_2}$$

If you use a table of logarithms you can solve dB problems using these formulas. For example, what is the dB gain if the input is 10 watts and the output is 20 watts? We have already given you the information to obtain an approximate answer of 3 dB. But let's try this problem using the first dB formula:

$$dB = 10 \log \frac{P_1}{P_2}$$

$$dB = 10 \log \frac{20}{10}$$

$$dB = 10 \log 2$$

From a log table, pocket calculator, or slide rule, if we can determine that the log of the number 2 is 0.301. So, ten times 0.301 means 3.01 dB is exactly twice the power. If the power input were 20 watts and the output 10 watts, the ratio is still equal to 2:1, or 3.01 dB, but now it is a loss of 3.01 dB, which may be expressed as −3.01 dB. You may not be given dB problems to work in an Amateur test, but you might! In any case you might want to memorize these ball-park dB values:

1 dB = 1.25 times the power (a 25 percent power increase)

3 dB = 2 times the power (a 100 percent increase)

6 dB = 4 times the power

9 dB = 8 times the power

10 dB = 10 times the power (exact)

20 dB = 100 times the power (exact)

30 dB = 1000 times the power (exact)

If you have a beam antenna with a 20 dB gain and you feed it 100 watts of rf ac, how much more power does it put out in its direction of maximum radiation? ____________. Wow! Where can I get an antenna *like that?*

FCC test topics

The following Technician/General test topic is discussed in this article, but should be understood by Advanced applicants also:

- decibels

The following Advanced class test topics are discussed in this article:

- amplifiers, classes A, AB, B, C, characteristics
- common-emitter class A transistor amplifiers, bias network, signal gain, input and output impedances
- common-collector class A transistor amplifier, bias network, signal gain, input and output impedances.

For more information on these subjects it is recommended that you refer to a textbook such as *Electronic Communication*, by Robert L. Shrader, McGraw-Hill Book Company, available through Ham Radio's Bookstore, and to radio handbooks.

ham radio

HAM CALENDAR

April

SUNDAY | MON | TUES | WED | THUR | FRI | SATURDAY

W1AW Schedule

October 25, 1981-April 24, 1982 — MTWThFSSn = Days of Week — Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule:

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn. 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn. 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

1

SAROC CONVENTION, Las Vegas, NV. *Contact W7PBV* — 1-4.

2

3

SP-DX Contest, CW — 3-4.

ARRL Open CD Party, Phone — 3-4.

ARRL International EME Competition — 3-4.

LINCOLN TRAIL ARC Convention, Elizabethtown, KY. Contact KA4BYA — 3.

MISSOURI STATE Convention, Kansas City, MO. Contact WA8KUH — 3-4.

CENTRAL ARKANSAS REN, Inc. Convention, Little Rock, AR. Contact W5RXU — 3.

MEMPHIS MINI-FEST, Pipkin Bldg., Mid South Fairgrounds, Memphis, TN. For information contact K4FZJ — 3.

4

5

WEST COAST BULLETIN — 9 PM PDT (8 PM PST - 0400 UTC) 3540 KCS A-1, 22 WPM — 5.

6

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

7

DX-YL to North American YL Contest, CW. For information contact WA6WZN — 7-8.

8

9

10

MISSOURI VALLEY AMATEUR RADIO CLUB Pony Express Day. Contact W0NH — 10.

COMMONWEALTH CONTEST sponsored by Canadian Amateur Radio Federation. Contact P.O. Box 2172, Station "D", Ottawa, Ontario, K1P 5W4, Canada — 10-11.

11

12

13

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

14

DX-YL to North American YL Contest, CW. Contact WA6WZN — 14-15.

15

W1AW QUALIFYING RUN — 15.

16

17

SP-DX Contest, phone — 17-18.

QRP ARCI QSO Party — 17-18.

ARRL Open CD Party, CW — 17-18.

WELLESLEY AMATEUR RADIO SOCIETY's Auction, Wellesley, MA. Talk in on 63-03, 04-64 and 52. Contact WA1YHV 17.

ARRL STATE CONVENTION, Jackson, MS. Contact KC5VD — 17-18.

TRENTON COMPUTER FESTIVAL. Contact TCF-82, Trenton State College, Hillwood Lakes CN550, Trenton, NJ 08625 — 17-18.

GREAT BAY RADIO ASSOCATION Annual Hamfest-Flea Market, Somersworth Armory, Somersworth, NH. Contact N1EX — 17.

SOUTHERN CALIFORNIA DX CLUB's 1982 International DX Convention, Holiday Inn, Visalia, CA. Contact N6IC — 17-18.

NORTH TEXAS HIGH FREQUENCY ASSOCIATION Novice Mini-Expedition. Contact KC5YN — 17-18.

18

RALEIGH ARS CONVENTION, *Raleigh, NC. KB4RV* — 18.

MOULTRIE AMATEUR RADIO KLUB's Annual Hamfest, Moultrie (IL) County 4-H Center Fairgrounds. Contact N9COK — 18.

QUAD CITIES AMATEUR RADIO CLUB special events station. For information contact N9BKY — 17-18.

19

WEST COAST BULLETIN — 9 PM PDT (8 PM PST - 0400 UTC) 3540 KCS, A-1, 22 WPM — 19.

20

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

21

22

23

DAYTON HAMVENTION, Dayton, Ohio. *Contact WA8KNM, General Chairman*, P.O. Box 44, Dayton, OH 45401 — 23-25.

24

ARRL MORNING SPECIAL — 24-25.

25

W1AW QUALIFYING RUN — 25.

ROCK RIVER AMATEUR RADIO CLUB's Annual Hamfest, Dixon, IL. Talk in on 146.25 simplex. Contact WD9CJB — 25.

26

27

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

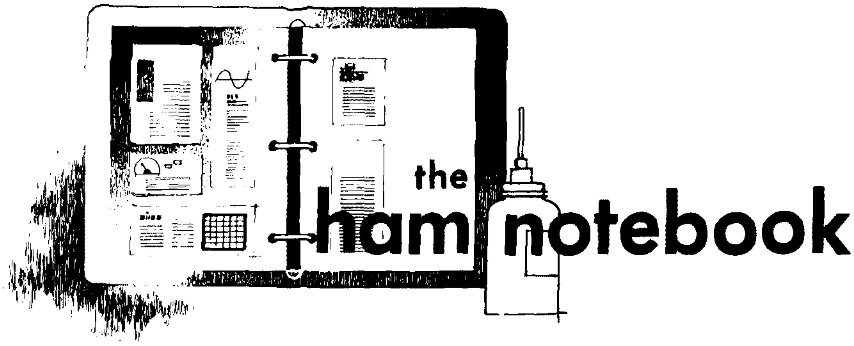
AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

28

29

30

*See Coming Events



binary coded decimal addition

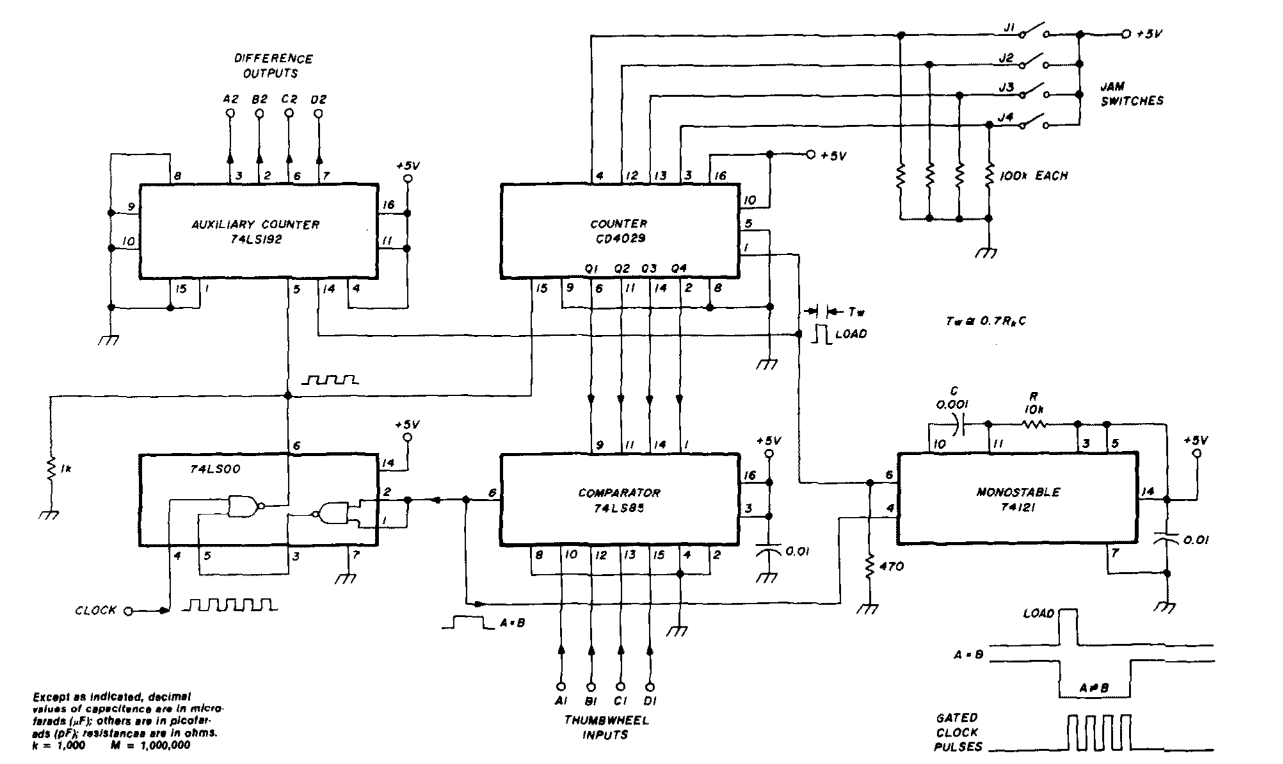
In the course of typical Amateur Radio do-it-yourself projects, you may seldom encounter a requirement for a binary adder. But if you should, the CD4008 is a logical choice if you prefer CMOS. However, the 4008 operates in pure binary format and is not intended to be used for BCD arithmetic.

I recently encountered the need to add one binary coded decimal number to another. The requirement resulted from the desire to drive a seven-segment LED display from a BCD thumbwheel and also a divide-by-*n* IC in a frequency synthesizer. Sure enough, in true Murphy's Law fashion, these two requirements were not compatible — that is, unless a fixed BCD number was first added to the thumbwheel number for the divide-by-*n* circuit.

A search through all available handbooks failed to identify an integrated circuit dedicated to adding in BCD. Rather than resorting to use of more exotic means to resolve this dilemma, such as by the use of a PROM for example, a combination of five readily available and inexpensive integrated circuits was assembled. What emerged is shown schematically in **fig. 1.** Despite the fact that the circuit shown is a hybrid combination of CMOS and TTL (they were available in the "goodie" box), from the first time power was applied, performance was flawless.

The operation of the BCD "adder" is as follows:

Assume that initially the *Q* outputs of the 4029 counter agree bit-for-bit with the thumbwheel output bits at the comparator input terminals. This sets the 74LS85 $A = B$ output high, which in turn prevents clock pulses from reaching the 4029 counter. This is a static situation that will persist



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

fig. 1. Circuit diagram of the BCD adder.

until such time as the thumbwheel switch setting is changed.

When the thumbwheel setting is changed, the falling edge of $A = B$ activates the 74121 monostable, which in turn generates a single LOAD or PRESET-ENABLE pulse. This pulse presets the 4029 counter so that its Q outputs agree with the JAM inputs. In other words, instead of being reset to zero, the counter is preset to some binary number equal to or greater than zero, according to the settings of the JAM switches.

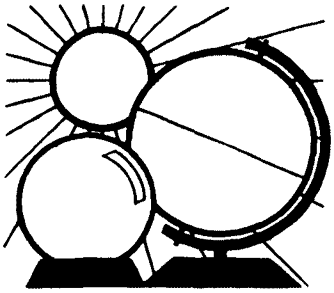
At the same time, the comparator $A = B$ output is LOW, and the NAND gate is open, allowing clock pulses to reach the 4029 input terminal. Thereafter, the 4029 Q outputs change, starting from their preset values, until they again agree with the thumbwheel bits. At this time, the comparator's $A = B$ output goes high, thus interrupting the train of clock pulses and freezing the contents of the counter.

The number of clock pulses necessary to re-establish this static $A = B$ state depends upon the *difference* between the thumbwheel number and the JAM number. If, for example, the number nine (1001) is dialed, and the JAM number selected is three (0011), the number of clock pulses gated to the 4029 counter will be $1001 - 0011 = 0110\ (9 - 3 = 6)$.

The gated pulses are also fed to an auxiliary counter, a 74LS192, which has its DATA inputs hard-wired to zero. Each time it receives a LOAD pulse from the monostable, it will reset to zero and accumulate a count numerically equal to the number of the clock pulses in the train. In the example above, the 74LS192 Q outputs will read 0110, or six, after being reset to zero, which is exactly the desired result.

The 74LS192 provides a *difference* output equal to the thumbwheel number minus the JAM number. Would it not therefore be more appropriate to call this circuit a SUBTRACTOR? After all, it's the difference that counts.

Norman J. Foot, WA9HUV



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

April brings a continuation of equinoctial propagation conditions and so could be a ball — remember last year's March and April? One cannot expect a duplication of last year, but be prepared to take advantage of the situation because there is good probability that something will happen. The sun/earth alignment makes for maximum ionospheric effect from solar wind particles released from the sun. The periods in April that look good for geomagnetic disturbances and erratic ionospheric movements are around the 10th, 19th, and 29th. These last two are associated with periods of solar flares and a 27-day solar activity maximum.

For the first week and a half of the forecast period the lower bands will probably be the best for DX. The higher bands are expected to improve the last weeks of the month both for trans-equatorial paths and north/south paths. North/south paths are enhanced the day or two before a disturbance; then the trans-equatorial paths are enhanced during the disturbance. The former is hard to recognize except by the presence of very low A and K geomagnetic indexes and by the use of beacons (see last month's DX Forecaster).

Other geophysical phenomena which may be of interest to DXers this month are the moon and meteor showers. The perigee of the moon's orbit (for moon-bounce DX) is on the 25th at 2100 hours; the moon will be at full phase on the 8th at 1018 hours. There will be short meteor shower, the Lyrid, on April 20-22. The rate is five per hour, hardly a real help for meteor-scatter DX. But a bigger shower, the Aquarid, starts before the end of the month, peaks on May 5, and ends by mid May. Its rate is 10 to 30 per hour.

Let's take a look at last year's spring equinox DX season. Using 6-meter contacts reported to *HR Report* as an indicator of good DX conditions, let's check on the openings and accompanying solar and geomagnetic conditions. With the solar flux above 240 and a mild geomagnetic disturbance in progress on February 28, a dip in the flux increased the disturbance so that a southern Africa to northern Europe trans-equatorial path opened up. At the same time, Liberia to the southwestern U.S.A. in a low-latitude east/west path was also good. On March 1st and 2nd other trans-equatorial paths from southern Africa to Europe and South America to the U.S. were open. After a quiet 3rd and 4th, a large disturbance with aurora arrived on the 5th and 6th with Columbia/Caribbean stations working into the U.S. On March 7th, the South America to Japan path was a big trans-equatorial opening.

The next disturbance, on March 13-15, found Ascension Island making over one hundred Japanese contacts; the flux was still above 200. Argentina and Chile had trans-equatorial openings all three days. There were good DX openings between Australia/New Zealand and the U.S. on the 14th and 16th. By the 21st and 22nd, the mid-latitude ionosphere was enhanced just before the commencement of the March 24-26 disturbance at low solar flux; east/west paths from the U.S. to Liberia, from Southern Africa to Hawaii, and from Canada/the Caribbean/French Guiana to Japan were open. The disturbance was very effective on the 26th between Southern Africa and Europe and between Australia/New Zealand and the Caribbean as the flux came back up above 200 again. LU3EX worked 550 JAs during the first half of March.

On the 6th of April the southern Africa/Hawaii path came alive again as the solar flux peaked on up to 276. From April 11 to 14 there was such a big storm most DX was wiped out, but a lesser disturbance on April 19-21 had French Guiana working Australia and southern Africa at the same time. Mexico worked Australia and New Zealand. The solar flux was about 200 during this disturbance. You can see how our solar-ionosphere connection really gives our DX hobby its interesting openings. Some geophysical rules of thumb, WWV flux and geomagnetic values, and beacons to use as tools can enhance the fun. Good DXing this month.

band-by-band forecast

Six meters should provide frequent band openings with a peak during the early afternoon hours on many days.

(Continued on page 72)

WESTERN USA

GMT	PST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	4:00	10	15	10	10	10	10	10	15
0100	5:00	10	20	10	10	10	10	10	15*
0200	6:00	10	20	15	10	10	10	10	15
0300	7:00	10	20	15	10	15	10	10	15
0400	8:00	15	20	15	20	15	15	10	15
0500	9:00	15	20*	15	20	15	15	15*	15
0600	10:00	20	20	15	20	20	15	15	20*
0700	11:00	20	20*	20	20	20	15	15	20*
0800	12:00	20	20	20	20	20	20	20	20
0900	1:00	20	—	20	20	20	20	20	20
1000	2:00	20	—	20	20	40*	20	20	20
1100	3:00	20	—	—	20	40	40	20	—
1200	4:00	20	20	—	20	40	40	20	—
1300	5:00	20	20	—	20	40	40	20	—
1400	6:00	20	15	—	15	—	20	20	—
1500	7:00	20	15	—	15	—	20	20	—
1600	8:00	15	15	—	10	—	20	40*	20
1700	9:00	15	15	—	10	—	20	—	20
1800	10:00	15	15	15*	10	—	20	—	20
1900	11:00	15	15	15	10	15	15	—	15
2000	12:00	15	15	15	10	10	15	—	15
2100	1:00	—	15	15	10	10	10	15	15
2200	2:00	—	15	15	10	10	10	10	15
2300	3:00	10	15	15	10	10	10	10	15

APRIL

MID USA

MST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN	CST
5:00	15	20*	10	10	10	10	10	15	6:00
6:00	15	20	15	10	15	15*	15	10	7:00
7:00	15	20	—	10	15	15	15	10	8:00
8:00	15	20	—	10	15	15	15	15	9:00
9:00	15	20	—	10	15	15	15	15	10:00
10:00	20	20	—	15	20	15	15	15	11:00
11:00	20	20	—	15	20	20	15	20*	12:00
12:00	20	20	20	15	40*	20	15	20	1:00
1:00	—	20	20	20	40*	20	20	—	2:00
2:00	—	20	20	20	40	20	20	—	3:00
3:00	—	20	20	20	40	40	20	—	4:00
4:00	—	20	—	20	20	40	20	—	5:00
5:00	—	20	—	20	20	40	20	20	6:00
6:00	20	20	—	—	20	20	20	20	7:00
7:00	20	20*	—	—	—	20*	20	20	8:00
8:00	20	20*	15	15	—	20	40	20	9:00
9:00	20	20*	15	15	—	20	40	20	10:00
10:00	15	15	15	10	—	20	40	—	11:00
11:00	15	15	15*	10	15	15	—	—	12:00
12:00	—	15	15*	10	10	15	—	—	1:00
1:00	—	15	10	10	10	10	15	15	2:00
2:00	—	15	10	10	10	10	10	15	3:00
3:00	—	15	10	10	10	10	10	15	4:00
4:00	15	15	10	10	10	10	10	15	5:00

EASTERN USA

EST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE CARIBBEAN S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
7:00	15	15	10	10	15	—	10	10
8:00	—	15	15	10	15	15	10	15
9:00	—	20	—	15	15	15	10	15
10:00	—	20	—	15	15	20*	10	10
11:00	—	20	—	15	20	20	15	15
12:00	20	20	15	15	20	20	15	15
1:00	20	20	15	20	20	20	15	20
2:00	—	20	20	20	20	20	15	20
3:00	—	20	20	40*	20	20	20	—
4:00	—	20	20	40*	20	40	20	—
5:00	—	20	—	20	20	40	20	—
6:00	—	—	—	20	—	40	20	—
7:00	20	—	—	20*	—	40	20	—
8:00	20	15	20	15	—	20	20	20
9:00	20	15	15	15	—	20	—	20
10:00	20*	15	10	10	—	15	—	15
11:00	15	15	10	10	—	10	—	—
12:00	—	15	10	10	—	10	—	—
1:00	—	15	10	10	—	15*	—	—
2:00	—	15*	10	10	15	15	20	—
3:00	—	15	10	10	10	—	15	15
4:00	—	15	10	10	10	—	10	15
5:00	15	15	10	10	10	—	15	15
6:00	15	15	10	10	15	—	15	10

*Look at next **higher** band for possible openings.

Trans-equatorial north/south paths will be the best. Your guide to possible openings will be strong openings on 10 meters and high values of solar flux.

Ten and fifteen meters will be loaded with good DX signals from morning until early evening hours almost every day. Times of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day than 10 meters. So hit 10 first and finish off with 15. The lengthening of the daylight will be noticed as these bands open up a little sooner and stay open longer in the day.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens to the east as the sun rises and extends into the late evening hours to the west. Geomagnetic disturbances do not affect this band as much as the higher ones, but still look for unusual trans-equatorial DX locations to be coming through once in a while. One-hop trans-equatorial DX of 5,000 to 7,000 miles (8,000 to 11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have short skip during daylight hours and turn to DX after dark. The bands will open to the east soon after sundown, swing more to the south to Latin America about midnight, and end up to the Pacific areas during the hour or so before dawn. On some nights these bands will be as good as during the winter DX season. The coastal regions usually have the edge for working rare DX on these bands.

One-sixty meters will probably have many nights that will remind you of last summer's noise. However many good nights are left for working DX before this summer's noise comes to stay. Many stateside stations are fair game as DX on this band during this season.

ham radio

A useful instrument
that does a good job
on ham-band inductances

easy-to-build
inductance meter

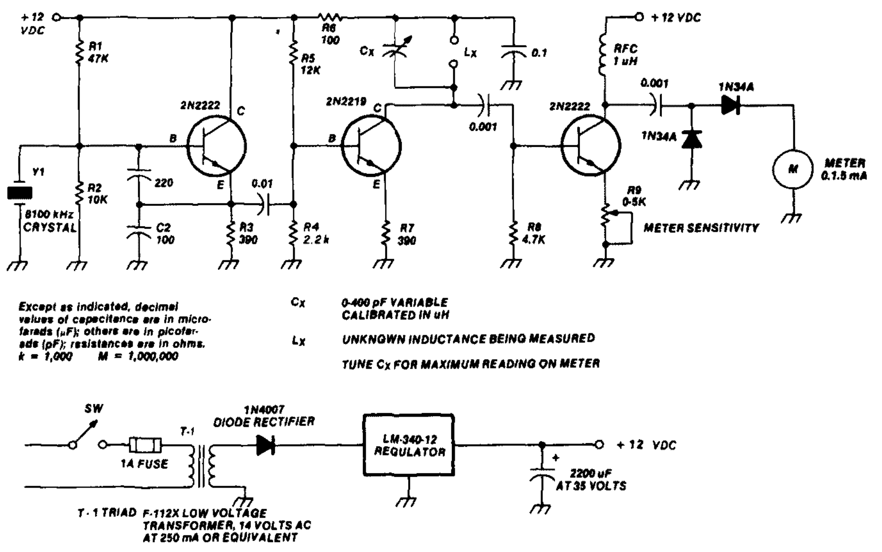


fig. 1. Schematic of the inductance meter, which uses a crystal oscillator on 8100 kHz.

This handy instrument will permit you to measure inductance from 0.5 μH to about 10 μH by reading a capacitor dial. I came up with this idea for my own work bench after searching for a good circuit for measuring inductance. This device does the job for the ham bands, and I hope you will like it as much as I do.

description

This inductance meter uses a crystal oscillator on a frequency of 8100 kHz (see **fig. 1**). The oscillator drives an amplifier. The unknown inductance is placed in the collector lead, and a capacitor across it is tuned for resonance. The dial is calibrated in μH so that the inductance can be read directly.

Another amplifier is used to build up the r-f voltage to operate the 0 to 1.5 mA meter used for tuning to a peak for resonance. A more sensitive meter (such as a 0-50 μA) could be used by shunting a 120-ohm resistor across it, if that is what you happen to have in the junk box.

I suppose the first question that will be asked is, "Why use 8100 kHz for the crystal oscillator?" Well, a surplus 8100-kHz crystal is cheaper to buy than one

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037

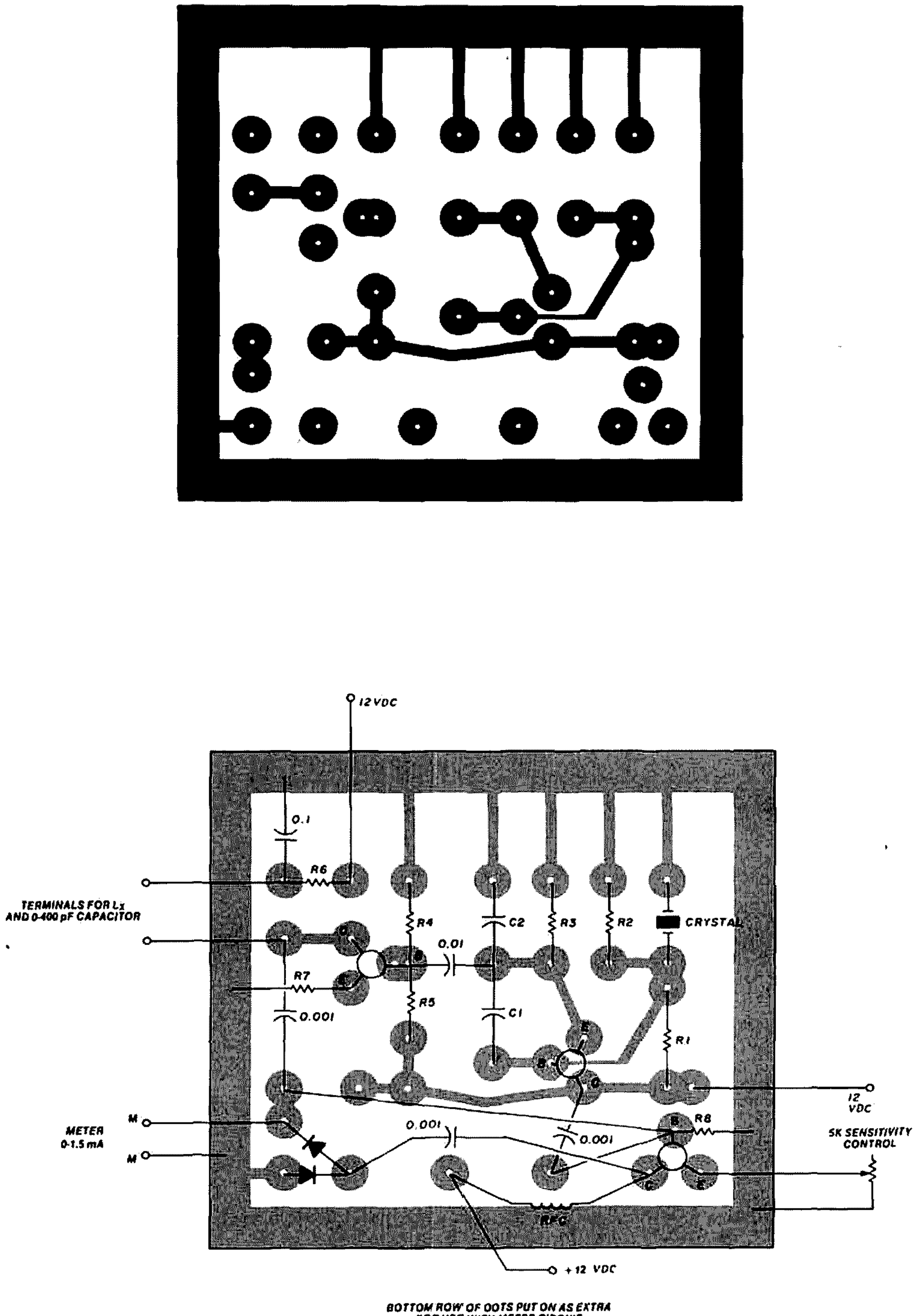


fig. 2. Printed-circuit board and parts placement for the inductance meter.

table 1. Capacitor calibration setting in μH.

pF	3500 kHz μH	7000 kHz μH	8100 kHz μH
10	200	51.6	38.5
20	165	25.7	19.2
30	70	17.2	12.8
40	52	12.9	9.6
50	42	10.3	7.7
60	34	8.5	6.4
70	30	7.3	5.5
80	26	6.4	4.8
90	23	5.7	4.2
100	21	5.17	3.8
125	17	4.5	3.0
150	14	3.4	2.5
175	12	2.9	2.2
200	16.5	2.5	1.92
225	8.6	2.3	1.6
250	8.4	2.0	1.5
300	7.6	1.7	1.2
325	6.0	1.5	1.1
350	6.5	1.4	1.1
375	5.7	1.3	1.0
400	5.5	1.2	0.9

Note: The 8100-kHz crystal was used because of its range and availability. Calibrate variable capacitor for whichever crystal you have from this formula:

f = Hertz
L = Henrys
C = Farads
$4\pi^2$ = 39.5

$$L = \frac{1}{4\pi^2 \times f^2 \times C} = \frac{1}{39.5 \times f^2 \times C} = \frac{1}{(39.5)(7 \times 10^6)^2 (10 \times 10^{-12})}$$

Example: $7000\ kHz = \frac{1}{39.5 \times 49 \times 10} = 0.0000516, or\ 51.6\ \mu H$

for the ham bands. Also, if you examine the chart in **table 1**, you will see that the choice of a 10-400 pF capacitor covers a good range of inductances to be measured. Of course, it's your choice which span you want to cover. If another crystal frequency is used, calibrate the variable capacitor by using the formula in **table 1**. I was surprised to learn that this formula is not shown in most handbooks.

The accuracy of the dial reading in μH will only be as good as the accuracy with which you can measure the variable capacitor. A better way would be to check or calibrate the dial against known inductance values. Some suggestions on where to obtain inductances of known value are shown under the subheading calibration. (I found that Air-Dux coils did not correspond to the values shown in their listing, and I wouldn't use them for calibrating the meter unless they were measured first.)

construction

There is nothing difficult about building this tester once you've located the parts. Some sources for parts are listed at the end of the article. The printed-circuit layout I used is shown in **fig. 2**. I cut the board by gripping it between two pieces of angle iron and using a hack saw. Then I filed the edges, sanded the copper with steel wool, and used paper drafting tape for the masking. The dots were Avery self-adhesive color-coding labels that I bought at a stationery store. The wider tape I used for the border is Bishop precision-type 201-250-11, 1/4 inch × 20 yards (6.35 mm × 18.2 m). It's expensive, and yellow shelf-paper with stickum on the back can be used, if you prefer, by cutting it on a paper cutter.

The board was etched with ferric chloride, which takes about an hour, but the process can be speeded up by placing a lamp over the solution and juggling it around once in a while. Once the board has been etched and cleaned, by again scrubbing it with steel wool, it should be tinned with a hot soldering iron. Be careful not to apply to much heat, or the copper will come off! (There are other ways of tinning, using a solution.)

The holes can be drilled out using a No. 60 (1-mm) drill. The crystal socket was mounted using a spacer and a long 4-40 (M3) machine screw.

Before putting a unit in a box, test it out by determining if the crystal oscillator is working. Using FT-243 crystals, I found my values of C-1 and C-2 to be correct as shown. Handbooks call for other values, but they did not make the oscillator work for me. You can listen for the oscillator at 8100 kHz with a receiver or put an rf probe at the emitter output. You should have 1.5 volts of rf, enough to drive the following amplifier. The amplifier can also be checked by placing a coil in the collector, resonating it, and measuring with the probe at the collector. A coil with a value of 3-10 μH should be sufficient for this test.

I used germanium diode rectifiers to operate the meter because they provide more dc voltage than the silicon type. The 1N34A, 1N38, or 1N64 work well.

I used a Radio Shack cabinet, 5-1/4 × 3 × 5-5/8 inches (13.3 × 7.6 × 14.3 cm), to house all the parts including the power supply. Before installing the parts mount the capacitor on a piece of plastic to insulate it from the cabinet; use an insulated coupler and plastic shaft through a panel bushing for the dial knob. I used GR terminals with long shanks that went right up to the capacitor terminals. Make the leads as short as possible, because they become part of the inductance.

Once the amplifier has been finished it can be checked by advancing the sensitivity control and resonating a coil placed on the terminals. I put a 100-

table 2. Some values of Air-Dux coils which might be used to calibrate or check the dial. Values must be checked first.

Air Dux number	total inductance of coil (μH)
404	0.18
406	0.39
408	0.71
410	1.10
416	2.87
432	11.30
504	0.27
506	0.61
508	1.10
510	1.60
516	4.30
532	17.30
604	0.38
606	0.86
608	1.52
610	2.38
616	6.08
632	24.20
804	1.02
806	2.33
810	6.47
816	16.30
832	66.30

Other values of coils can be obtained by writing Illumitronic Engineering Corporation, 680 East Taylor Avenue, Sunnyvale, California.

ohm resistor in series with the control to limit the current reading and not ground the emitter. Most meters have the positive terminal on the left looking at the back. If your meter does not read, or reverse readings are obtained, turn the meter leads around. The meter dial plate is shown in **fig. 3**.

calibration

Several suggestions on calibrating the dial are given. I used a 0-400 pF capacitor, a BDC type out of Swan equipment, that I found at a flea market. The 0-365 pF units are more common and are available from J.W. Miller and Radio Shack.

One of the best ways of calibrating or checking your dial readings is to use the rf chokes listed below. They seem to be very accurate:

Miller rfc 420	0.22 μH
Miller rfc 220	0.82 μH
Miller rfc 144	1.72 μH
Miller rfc 50	8.20 μH
Ohmite Z-50	10.00 μH

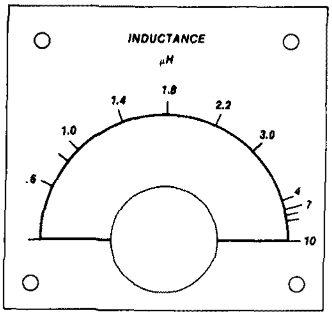


fig. 3. Inductance meter dial plate.

Other values of the type 4500 and 70F106AI chokes can be obtained from the J.W. Miller catalog (J.W. Miller, 19070 Royes Avenue, Compton, California 70224). If you know someone who can measure inductance, the Air-Dux line in the 400, 500, 600 and 800 series are also good to use. Some of the approximate values of Air-Dux are given in table 2.

table 3. Reference chart for other J.W. Miller coils that could be used for calibration.

J.W. Miller stock No.	inductance μH	Q
4580	0.10	70
4582	0.15	80
4584	0.22	95
4586	0.33	100
4588	0.47	105
4590	0.68	113
4592	0.75	115
4594	0.82	112
4602	1.00	58
4604	1.50	62
4606	2.40	63
4608	3.90	70
4609	5.50	70
4610	6.20	67
4611	8.20	67
4612	10.0	67
4622	10.0	70
4624	15.0	58
4628	39.0	93
70F106AI	2.0	
70F226AI	2.2	
70F336AI	3.3	
70F396AI	3.9	
70F476AI	4.7	
70F686AI	6.8	
70F826AI	8.2	
70F105AI	10.0	

See the catalog for a complete list of values in between. Contact J.W. Miller Co., Sales, Mr. Bill Courtney, 19070 Reyes Avenue, Compton, California 90224.

Table 3 gives values for some J.W. Miller coils, and **table 4** shows some typical toroid values. All these components are available from many sources throughout the country.

table 4. Some typical toroid values collected from magazine articles.

band	core	inductance (μH)	no. turns	enamel wire size AWG	(mm)
40 meters	T-50-2	13	50	28	(0.3)
20 meters	T-50-2	8	44	28	(0.3)
15 meters	T-50-2	4	25	28	(0.3)
10 meters	T-50-2	0.6	12	24	(0.5)

Note the red core is type 2, and the yellow core type 6.

core	inductance (μH)	no. turns	enamel wire size AWG	(mm)
T-68-1	0.5	10	22	(0.6)
T-68-6	0.5	8	20	(0.8)
T-68-6	0.7	12	22	(0.6)
T-68-6	0.8	13	26	(0.4)
T-68-6	1.0	14	20	(0.8)
T-68-2	1.2	13	20	(0.8)
T-68-2	1.8	19	22	(0.6)
T-68-2	2.0	20	22	(0.6)
T-68-2	2.1	22	22	(0.6)
T-68-2	6.0	32	24	(0.5)
T-68-2	7.0	32	24	(0.5)
T-68-2	21.0	56	24	(0.5)
T-68-2	24.0	60	28	(0.3)
T-50-2	0.57	7	26	(0.4)
T-50-6	0.60	12	24	(0.5)
T-50-2	1.70	17	26	(0.4)
T-50-2	0.9	11	20	(0.8)
T-50-6	2.4	25	26	(0.4)
T-32-2	0.28	8	22	(0.6)
T-32-2	0.37	9	22	(0.6)
T-32-2	0.8	14	22	(0.6)
T-32-2	1.0	22	22	(0.6)
T-32-2	2.6	25	26	(0.4)
T-32-2	3.0	27	26	(0.4)
T-32-2	6.0	37	28	(0.3)

Note: T-94 coil is 0.94 inch dia. (24 mm)
T-80 core is 0.79 inch dia. (20 mm)
T-68 core is 0.69 inch dia. (17.5 mm)
T-50 core is 0.50 inch dia. (12.7 mm)

Perhaps this little gadget is not the best way to measure inductance, but I find it does the job for most of my construction projects, especially for ham-band inductances.

Another reference for a final check of your dial: ARRL L/C/F Calculator Type A.

ham radio

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

OLD TIMERS — I need Vibroplex, McElroy, Logan and Johnson speed keys for my collection. Also need junkers for spare parts. K5RW, B.N. McEwen, 1128 Midway, Richardson, Texas 75081.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

BNC MALE CONNECTORS, silver plated, military surplus. Specify RG-58, RG-59, or 8X. 6/$5, postage paid. Colonel Russell, 9410 Walhampton, Louisville, KY 40222.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

I WOULD LIKE TO GET a copy of the manual, circuit diagram, crystal information for the Standard SR-C146, 2 meter handheld transceiver. I am willing to pay any reasonable compensation. Any information on where this documentation can be obtained, i.e. club, library, etc., will be appreciated. Dennis Sladen, VE1BZJ.

QSL ECONOMY: 1000 for $13. SASE for samples. W4TG, Box F, Gray, GA 31032.

TEKTRONIX 661 SCOPE: 4S1 d.t. sampling, 5T1 time base plug-ins; dc - 1 GHz $250. C-12 scope camera $175. aL60 spectrum analyzer p-i with manual "as is". $125. A.P. Towbin, 436 Orange St., New Haven, CT 06511.

SEND 9½" SASE for surplus parts and equipment catalog. Bill Williams, P.O. #7057, Norfolk, VA 23509.

MEISSNER SIGNAL SHIFTER, manual, coils, best offer or trade for good receiver. KA4TCV, 105 E. King Arthur Drive, Port Richey, FL 33568.

OVERPRINTED — 1981 Fox-Tango Club Newsletters. Sixty loose-leaf pages packed with modifications and information on Yaesu rigs. Only $6 while they last. Also a few 1980 sets at $5. (Overseas add $3 each, airmail.) N4ML, Box 15944, W. Palm Beach, FL 33406.

SALE — HW-16 $125 (w/crystals $150). 2 Johnson matchbox tuners, best $50, other (needs *repair*) $25. Heath 2 meter mobile amp $30. 10-40 vertical $25. You pay shipping. KA4EBW, Jim Howell, 18 Dan Street, Salisbury, NC 28144.

SATELLITE TELEVISION: Information on building or buying your earth station. Six pages of what's needed, where to get it, etc. $4.00 to Satellite Television, RD #3, Oxford, NY 13830. Parabolic antenna construction book also available. Send SASE for details.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Williams, PO #7057, Norfolk, VA 23509.

MODERNIZE YOUR TRANSCEIVER — With Protronics RIT kit, for only $15.90 postpaid. Kit *comes complete* with custom potentiometer and simple step by step instructions. Add $2.50 for XIT. Visa/Master Charge. Protronics, 20 Monte Vista, Buckley, WA 98321. 1-206-829-0056.

MAKE HAM RADIO FUN! Supplement your learning programs with a motivational hypnosis cassette. Tape #3, *Learning the Code;* Tape #4, *Breaking the Speed Barrier;* Tape #7, Electronic Theory. Free catalog. For tapes, $10.95 each to Gem Publishing, 3306 North 6th St., Coeur d-Alene, ID 83814.

CORDLESS TELEPHONES — Low prices, all major brands. Inquiries or Visa/MasterCard orders call (206) 743-3977 or Write Trinetics, Box 6005, Lynnwood, WA 98036.

VERY in·ter·est·ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

MICROWAVE CONVERTERS, decoders. Catalog 20¢. G.W. Electronics, P.O. Box 688, Greenwood, Indiana 46142.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

SATELLITE TELEVISION...HOWARD/COLEMAN boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-3, HT-19, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

WANTED: Surplus 1-3 KW HF transmitter type FRT-15, Collins TDH or equivalent. P.J. Plishner, 2 Lake Ave. Ext., Danbury, CT 06810. WA1LDU.

YAESU OWNERS: Join your International Fox-Tango Club, now in its eleventh year. Calendar year dues still only $8 US, $9 Canada, $12 airmail elsewhere. Don't miss out, get 1982 top-rated FT Newsletters packed with modifications monthly, catalog of past modifications, free advertisements, technical consultation, FT net (Saturdays, 1700Z, 14.325 MHz), more. Go Fox-Tango! To join, send dues to FT Club, Box 15944, W. Palm Beach, FL 33406.

GET OFF YOUR EARPHONES and start laughing. "Slices of Ham" is a light-hearted look at Amateur Radio. N1ADX has collected more than a dozen short stories to brighten your shack. For witty, technical humor send $5 (mailed anywhere). Add $1 for airmail overseas. Massachusetts residents add sales tax. Parsley Press (H), Box 94 Turnpike Station, Shrewsbury, MA 01545 USA.

Coming Events

ACTIVITIES

"Places to go..."

CALIFORNIA: The Southern California DX Club's 1982 International DX Convention, Saturday, April 17 and Sunday, April 18, Holiday Inn, Visalia. Pre-registration $35.50 and for first 500 may include a surprise gift. Pre-registrations received by April 9 are eligible for pre-registration prize. Door registration $37.00. Registration includes admittance to all events, Saturday banquet, Sunday champagne brunch and a chance for many prizes. Extra chances may be purchased. Make all checks payable to: Southern California DX Club. For information: Don Bostrom, N6IC, 4447 Atoll Avenue, Sherman Oaks, CA 91423.

CONNECTICUT: The fifth annual P.V.R.A. Flea Market, Sunday, May 2, George Penny High School, East Hartford, exit 91 off I-86. Tables $8.50; admission donation $1.00. 10 AM to 4 PM. For information or advance tables: Arnie, K1NFE, PO Drawer M, Plainville, CT 06062.

ILLINOIS: The Centralia Wireless Association's annual Hamfest, Kaskaskia College Gym, 3 miles N.W. of Centralia, Sunday, May 2. Talk in on 147.27/.87 and 146.52. Doors open 7 AM. No charge for flea market/exhibit space. Free admission; free parking. Refreshments available. Prizes throughout the day. Prize tickets $1.00 each; 6/$5.00. SASE for ticket orders to Centralia Wireless Association, Hamfest Tickets, PO Box 1166, Centralia, IL 62801. For information: Bud King, WB9QEG, (618) 532-6606. Lou Hodges, W9IL (618) 533-4724 or write CWA, Inc. at above address.

ILLINOIS: The Lake County Radio Control Club's Radio Control Expo V; static model airplane contest, Saturday, May 1 and Sunday, May 2, Lakehurst Shopping Center, Rt 120 and 41, Waukegan. Saturday 10 AM to 5:30 PM; Sunday 12 noon to 5:00 PM. Over 100 model airplanes competing for ribbons and trophies. All contestants eligible for door prizes. RC car and tank demonstrations. The Palos Air Show Team will give a 1-1/2 hour outside show. For entry information call John Russell (312) 249-3060 or Ed Fuerst (312) 336-7505.

ILLINOIS: The Moultrie Amateur Radio Klub's 21st annual Hamfest, April 18, Moultrie County 4-H Center Fairgrounds, 5 miles east of Sullivan on Cadwell Rd. Indoor and covered outdoor flea market, no charge to vendors. Talk in on 146.94 and 146.655/.055. For information: Ralph Zancha, N9CDK, PO Box 55, Lovington, IL 61937. (217) 873-5287.

ILLINOIS: The Rock River Amateur Radio Club's 16th annual Hamfest, Sunday, April 25, Lee County 4-H Club Center, one mile east of junction of Rts 52 and 30, South of Dixon. Advance tickets: $2.00 donation; $2.50 gate. Grand prize $500 cash; second prize $200 cash (need not be present to win). Hourly door prizes (must be present to win). Talk in on 146.52 simplex. For advance tickets: Ed Webb, WD9CJB, 618 Orchard, Dixon, IL 61021.

MASSACHUSETTS: Quannapowitt Radio Association (QRA) will hold an indoor/outdoor Hamfest, Saturday, May 1, 9 AM to 4 PM, South Hall Fire Station, corner of Salem and Summer Sts, Lynnfield. Admission: $1.00 door. Tables $7.00 door; advance $5.00. Food available. Talk in on 146.19/79 or 52. For details: Dave Meldrum, KA1MI, 26 Cedar Ln., No. Andover, MA 01845.

MASSACHUSETTS: A general Amateur Radio outdoor Flea Market, May 2, sponsored by the New England Amateur TV Group, Freeport Hall, Dorchester, just off S.E. expressway. Rain or shine. Admission: $1.00. Sellers $4 pre-registration by April 25 to NEAT, PO Box 406, Boston, MA 02102. $7 at gate. Talk in on 145.29 Repeater or 52 direct.

MASSACHUSETTS: The Wellesley Amateur Radio Society's annual auction, Saturday, April 17, Wellesley High School Cafeteria, Rice Street, Wellesley. Talk in on 63-03, 04-64 and 52. Doors open 10 AM. Contact: Kevin P. Kelly, WA1YHV, 7 Lawnwood Place, Charlestown, MA 02129.

MASSACHUSETTS: The Fall River Amateur Radio Club's Flea Market, Sunday, May 23, American Legion Hall, Freetown, 10 AM to 4 PM. Flea market spaces $7.00 advance, $9.00 door (price includes 2 admissions). Free coffee. Talk in on 147.63/03 and .52 direct. Check or money order to Fall River Amateur Radio Club c/o Ann M. Carro KA1DNB, 652 Old Colony Terrace, Tiverton, RI 02878.

MINNESOTA: The Arrowhead Radio Amateur Club's annual swapfest, Saturday, May 8, First United Methodist Church, 230 East Skyline Parkway, Duluth. Admission: $2.00 advance; $2.50 door. Door prizes include an Icom 2AT. Raffle prizes include a Regency D100 programmable scanner and portable B/W TV. Raffle ticket donation $1.00; 6/$5.00. Reserved 4-foot tables $3.00 advance, $3.50 door. Doors open 10 AM to 3 PM. Food, free parking, hourly prize drawings. Talk in on 34/94. For information, advance reservations, raffle tickets: SASE to Jerry Frederick, N0BNG, 1127 — 104th Avenue West, Duluth, MN 55808.

MISSISSIPPI: The Jackson Amateur Radio Club will host the ARRL State Convention, Saturday, April 17, noon to 5 PM and Sunday, April 18, 8 AM to 2 PM, Raymond Road National Guard Armory, Jackson. Forums, net and special activity group meetings, exhibits, prizes and flea market. Food available. Free admission. Swap tables $5.00 each day. Talk in on 146.16/76, 146.52 and 3987.5. For information/table reservations: Don Elder, KC5VD, 2806 N. Mill St., Jackson, MS 39216. (601) 362-0336.

NEW HAMPSHIRE: The Great Bay Radio Association's 2nd annual Hamfest-Flea Market, Saturday, April 17, Somersworth Armory, Somersworth, 9 AM to 3 PM. Antique radios and computers displayed. Hourly door prizes. Grand raffle for Radio Shack color computer and other prizes. Refreshments available. Free parking. Entrance fee $1.00 per person (ticket counts for door prizes). For information/registration: Dick Sedgewick, N1EX, (603) 742-3703 or write Great Bay Radio Association, Rt. 16, Dover, NH 03820.

NEW JERSEY: The Tri-County Radio Association's annual Indoor Hamfest/Flea Market, May 2, 9 AM to 4 PM, Passaic Township Youth Center, Valley Road, Stirling. Donation $2.50. Tables $6.00. Hot food and refreshments available. An ICOM IC-2AT will be one of many door prizes. Talk in on 247.855/.255 and 146.52. For information/table reservations: Jack Sammarco, 2062 Emerson Ave., Union, NJ 07083 or call Herb Klawunn, W2CHA (201) 647-3461.

NEW JERSEY: The 7th Trenton Computer Festival, Saturday and Sunday, April 17/18, 10 AM to 5 PM, Trenton State College, Trenton. Exhibits, flea market, technical sessions, free short courses on Sunday. Admission: $5.00 ($3.00 students). For information: TCF-82 Trenton State College, Hillwood Lakes CN550, Trenton, NJ 08625. (609) 771-2487.

NEW YORK: The Southern Tier Amateur Radio Club's 23rd annual Hamfest, Saturday, May 1, Owego Treadway, Owego. 9 AM to 5 PM. Outside flea market, dealer displays, door prizes and refreshments. Talk in on 146.22/82 and 146.16/76. For information: Craig England, KF2X, RD #1, Box 144, Vestal, NY 13850.

OHIO: The 13th annual B*A*S*H will be held on the Friday night of the Dayton Hamvention, April 23, at the Convention Center, Main and Fifth Streets. Parking in adjacent City Garage. Admission is free to all. Sandwiches, snacks and C.O.D. bar available. Live entertainment provided for a super social evening. Don't miss it . . . Awards include a new synthesized HT and a synthesized pocket scanner. For further information contact the Miami Valley FM Assn., PO Box 263, Dayton, OH 45401.

SOUTH CAROLINA: The Greenville Hamfest sponsored by the Blue Ridge Amateur Radio Society will be held at the American Legion Fairgrounds, White Horse Road, 1/2 mile north of I-85 in Greenville, May 1 and 2. Admission $3.00 at the gate, no advance sales. Talk-in on 146.01/61 and 223.46/224.06. For further information write Hamfest Chairman, Gary D. Whidy, Rt. 6, Box 268, Travelers Rest, South Carolina 29690.

TENNESSEE: The Memphis Mini-Fest, Saturday only, April 3, 8 AM to 5 PM, Pipkin Bldg, Mid South Fairgrounds. Admission $1.00. Flea Market space $5.00 or 2 spaces $8.00. Bring own tables/chairs. Hospitality party

Saturday night. For further details: Mid South Amateur Radio Assn. President Clayton Elam, K4FZJ, 28 N. Cooper St., Memphis, TN. 274-4418 (days) and 743-6714 (nights).

TENNESSEE/VIRGINIA: The Bristol, Johnson City and Kingsport Amateur Radio Clubs' 2nd Tri-Cities Hamfest, May 1 and 2, Appalachian Fairgrounds, Gray. Forums, dealers, flea market. Only two hours away from the 1982 World's Fair that starts May 1. For further information: Tri-Cities Hamfest, PO Box 3682 CRS, Johnson City, TN 37601.

VIRGINIA: The Lynchburg Amateur Radio Club's annual Swapfest, May 2, Brookville High School, route 460 west of Lynchburg. Large covered tailgating area and plenty of food. Talk in on 146.01/146.61. Details via: PO Box 4242, Lynchburg, VA 24501.

WASHINGTON: The Yakima Amateur Radio Club's annual Hamfest, May 1 and 2, Ahtanum Youth Activities Park, Yakima. Doors open 9 AM Saturday. Dealers, a super prizes raffle, free swap and shop. Lunch available both days. Breakfast 6 AM Sunday. For information: David Pankey, N7BRB, 512 So. 7th Street, Yakima, WA 98901.

WISCONSIN: The Ozaukee Radio Club's 4th annual Swapfest, Saturday, May 8, Circle B Recreation Center, Highway 60, Cedarburg (20 miles north of Milwaukee), 8 AM to 1 PM. Admission $2.00 advance; $3.00 door. 8 foot tables $3.00. Door prizes, food, refreshments. For information or tickets: SASE to Ozaukee Radio Club, PO Box 13, Port Washington, WI 53074.

WISCONSIN: The 3F Amateur Radio Club's Swapfest, Saturday, May 8, 8 AM to 3 PM, Neenah Labor Temple. Admission $1.50 advance, $2.00 door. Tables $1.50 advance, $2.00 door. Prizes, food, beverages. Auction at end of day. Talk in on 146.16/146.76 and 146.52. A semi-formal banquet available Saturday evening, $8.00 per person to advance ticket holders only. For information or tickets: Mark Michel, W9OP, 339 Naymut Street, Menasha, WI 54952. (414) 722-4034 (after 0000Z).

KNOXVILLE TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

OPERATING EVENTS

"Things to do..."

APRIL 10: The Missouri Valley Amateur Radio Club's third annual Pony Express Day, from 1000 CST to 1900 CST commemorating the original running of the Pony Express from St. Joseph, Missouri to Sacramento, California. In addition, the Club is also offering a "wanted" poster of outlaw Jesse James as this will be the 100th anniversary of his death. Anyone contacting club station WØNH is eligible to receive both certificates. Phone frequencies: 10 Kc's from bottom of general phone bands on 15, 20, 40 and 75 meters. 10 meters - 28.575. CW: 28.150 on 10, 21.150 on 15 and 7.125 on 40. To receive certificates send two first-class stamps and a QSL card to Missouri Valley Amateur Radio Club, WØNH, 401 N. 12th Street, St. Joseph, Missouri 64501.

APRIL 17 & 18: A Novice Mini-Expedition. The North Texas High Frequency Association will be operating the Novice bands from Novice, Texas, from 1800Z Saturday to 1800Z Sunday. Call sign KC5YN will operate near center of the Novice bands at your calling speed. For a commemorative QSL send legal-sized SASE to North Texas High Frequency Association, Denton, Texas 76201.

APRIL 17 & 18: W9YCR, The Quad Cities Amateur Radio Club, Rock Island, Illinois, will operate a special events station commemorating the first bridge across the Mississippi River. W9YCR will be on the air from 1800 UCT Saturday through 1800 UCT Sunday. 80 - 10 meters. Frequencies: middle of CW portion of each Novice class band, as low as possible in the General CW portion of each band and 30 kHz up from lower edge of the General SSB portion of each band. For a commemorative certificate send QSL and business SASE to: Denny Spurgeon, N9BKY, 413 - 23rd Avenue, Moline, IL 61265.

MAY 7 & 8: The Indian River Amateur Radio Club in conjunction with the Florida Solar Energy Center at Cape Canaveral will participate in a "Sun-Day" exercise using club call, W4NLX/4 and, at that time, will be operating completely on solar power. 1300-1400 GMT, 40 meters, 7,250 to 7,275 kHz, SSB. 1400-2000 GMT, 15 meters, 21,350 to 21,375 kHz, SSB. For a certificate confirming contact or reception (free to each station or short wave listener sending a QSL) SASE (Foreign 1 IRC) to: Florida Solar Energy Center, "Sun-Day", 300 State Route 401, Cape Canaveral, FL 32920.

MAY 8: The Greater Fairfield Amateur Radio Association's special Dogwood Festival QSO Party. Members of the club (WB1CQO) will be on six Amateur bands to explain significance of the festival. 1300-2200 UTC or 9 AM to 6 PM EDST. SSB frequencies: 3.975, 7.235, 14.330, 21.420 and 28.710 MHz. FM: 146.55 simplex. For a special, commemorative QSL card send SASE or IRCs to QSL manager, Grace von Stein, KA1JT, 248 Euclid Avenue, Fairfield, CT 06432.

MAY 15: In observance of Armed Forces Day, an Amateur Radio station will be operating from the United States Air Force Museum at Wright-Patterson Air Force Base near Dayton, Ohio using the call sign, K8DMZ, from 1400Z to 2200Z on Saturday. Operators will work primarily in the General Class phone segments of 75, 40, 15 and 10 meters with periodic CW excursions to the Novice subbands. FM and SSB operation on 2 meters is planned. This will be the first time an Amateur Radio station has operated from the Museum in conjunction with a special event and to commemorate this, the Museum will issue a special certificate for each two-way contact.

MAY THROUGH OCTOBER: The 1982 World's Fair in Knoxville will feature a special events Amateur Radio station sponsored by The Tennessee Wireless Association. The station will operate all bands 160-2m, all modes and will be on display to the public. Guest operators are welcome subject to rules laid down by the chief operator. For details: Jerry Goodchild, K4DZR, 3701 Warner Dr., Apt. 213, Knoxville, TN 37912.

PLAYBOY RESORT at Great Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07631.

SCHOLARSHIPS: The Foundation for Amateur Radio, Inc., a non-profit organization with headquarters in Washington, DC plans to award nine scholarships for the academic year 1982-1983. The Foundation, composed of fifty local-area Amateur Radio clubs, fully funds two of these scholarships from the proceeds of the Gaithersburg (MD) Hamfest and administers, without cost to donors, two scholarships for the Quarter Century Wireless Association and one each for the Richard G. Chichester Memorial, The Radio Club of America, the Young Ladies' Radio League, the Edmund B. Redington Memorial and the Amateur Radio News Service. Radio Amateurs holding at least an FCC General Class license or equivalent may compete for one or more of these awards if they plan to pursue a full-time course of studies beyond high school and are enrolled or have been accepted by an accredited university, college or technical school. Awards range from $300 to $900. For additional information and application form, send letter or QSL postcard prior to May 31, 1982 to: Hugh A. Turnbull, W3ABC, 6903 Rhode Island Avenue, College Park, MD 20740.

NEW products

Transi-Trap lightning protection

The conventional air-gap lightning protector design affords virtually no protection to solid-state components, since it's breakdown voltage and response time are unpredictable because of the arc-forming characteristics of the molecules of air between electrodes in an air-gap protector.

By comparison, the Alpha Delta Transi-Trap gas tube protector design encloses the gap in a hermetically sealed ceramic tube filled with an isotope of known breakdown characteristics and response time. As a result, the variable and unpredictable nature of the ionized particles is minimized. This yields a protector design with a known response time of 100 nanoseconds and a predictable breakdown voltage with a tolerance of ± 15 percent, compared with the approximate breakdown tolerance of 100 percent for the air-gap. Also, breakdown voltage and response time are not affected by humidity, temperature, altitude, and pressure changes; they are with the air-gap.

The Transi-Trap protector design allows devices to be set to fire at the lowest possible lightning pulse level for maximum protection of solid-state receivers and transceivers (Model R-T protector), or at a higher voltage level for protection of amplifiers, both tube-type and solid-state (Model HV protector). By using special constant-impedance brass tubing design for the in-line circuitry, excellent performance through 500 MHz is realized (typically 0.1 dB loss at 500 MHz).

For more information, contact Alpha Delta Communications, 116A North Main Street, Centerville, Ohio 45459.

Big Ben mike stand

Mobile radio operators who use their equipment in the base station will find their job made easier by the new Big Ben Mike Stand by Valor Enterprises, Inc. The new mike stand allows the operator to convert his mobile microphone to a base station microphone.

Valor manufactures Big Ben microphone stands in both black (Model 221) or polished chrome (Model 221C). The stand is part of a complete line of personal and Amateur communications products and accessories offered by Valor Enterprises, Inc., West Milton, Ohio 45383. A complete catalog is available by calling 513-698-4195.

Commsoft Codem

The Commsoft Codem, a universal CW interface for personal computers, is now available for Radio Amateurs. The Codem provides an easy way to get your Morse code software on the air. Converting received CW audio to RS232 or TTL signal levels and RS232 or TTL signal levels to transmitter keying, the Codem doubles as a code practice oscillator and CW regenerator.

NEW products

A sharp 800-Hz bandpass filter, a-m detector and low pass filter are designed into the Codem to provide outstanding noise and QRM rejection. CW can be monitored using an internal 2-inch speaker or with an external high impedance earphone. Front panel sensitivity, tone and volume controls are provided. The Codem comes with a comprehensive manual that includes operating details and connection instructions. The Codem requires an external 9-Vdc power supply.

The price of the Codem is $124.95. The 9-Vdc supply is $9.95. Add $5.00 for shipping and handling. California residents add applicable sales tax. VISA and MasterCard orders accepted.

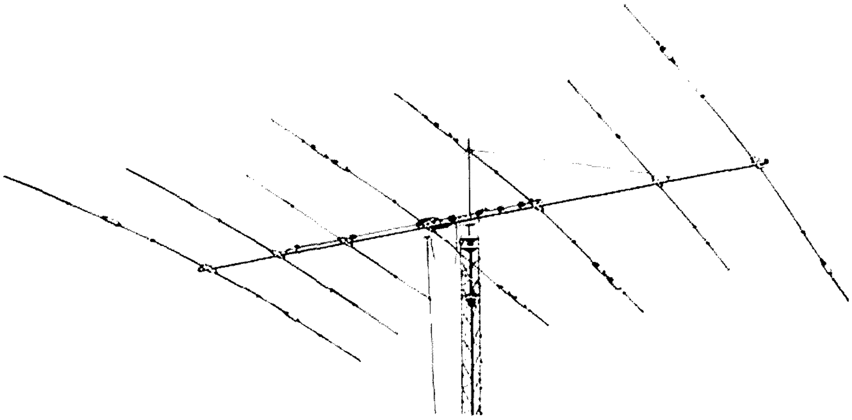
For more information, contact Commsoft, 665 Maybell Avenue, Palo Alto, California 94306; telephone 415-493-2184.

Hy-Gain tribander

Hy-Gain introduces the TH7DX, a broadband tribander based on the excellent front-to-back characteristics of the older TH6DXX plus the superior VSWR characteristics of a dual-driven element system. The combination produces an amazingly efficient broadband tribander without compromises.

During the development of the TH7DX, the company's engineering tests and research indicated that a higher average front-to-back ratio could be maintained on each band by employing a combination of trapped and monoband reflectors and directors rather than fully trapped parasitics. Also, the gain bandwidth was broader and average half-power beam width was smaller. Research also showed that other tribanders sacrificed gain and high front-to-back ratio to maintain a low VSWR across each band. And finally, none of the tested antennas covered all of the 10-meter band; most stopped at 29.2 or 29.4 MHz.

The new TH7DX features a dual driven element system that maintains a VSWR of less than 2:1 on *all* bands, including the entire 10-meter band. Both elements use Hy-Gain's efficient Hy-Q traps capable of handling power levels well in excess of the legal limits with a 2:1 safety margin. These traps permit element lengths of 0.225 wavelength on 10 meters, 0.203 wavelength on 15 meters, and 0.185 wavelength on 20 meters. The dual driven elements are fed directly with Hy-Gain's 50-ohm BN-86 balun. Hy-Gain's Beta Match provides a dc ground and matches each band to a



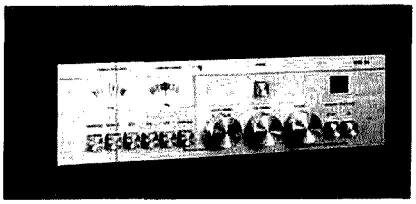
NEW products

VSWR of less than 1.5:1 at resonance. Rugged phasing lines and preformed feed straps facilitate easy assembly and consistent results.

The TH7DX, complete with stainless steel hardware, BN-86 balun and heavy duty boom-to-mast clamp, is priced at $499.95. For more information, contact Telex Hy-Gain, 9600 Aldrich Ave., So. Minneapolis, Minnesota 55420; telephone 612-884-4051.

Drake ESR24

The ESR24 earth station receiver has been introduced by the R.L. Drake Company, Miamisburg, Ohio. This 3.7-4.2 GHz receiver is designed for satellite television reception and features digital channel display, preset and variable audio subcarrier selector, AFC for stability, and full metering. For installation versatility, the down converter module (supplied) may be mounted internally or at the antenna. Accessories for the ESR24 include a remote control, a remote



tuning meter, and splash-proof housing. Attractive styling makes the ESR24 suitable for commercial or private installations. Price is under $1,000.

R.L. Drake is recognized for high technology Amateur Radio, commercial, and maritime communications equipment. For more information, contact R.L. Drake Company, 540 Richard Street, Miamisburg, Ohio 45342; telephone 513-866-2421.

ANNUAL ANTENNA ISSUE

ham radio magazine

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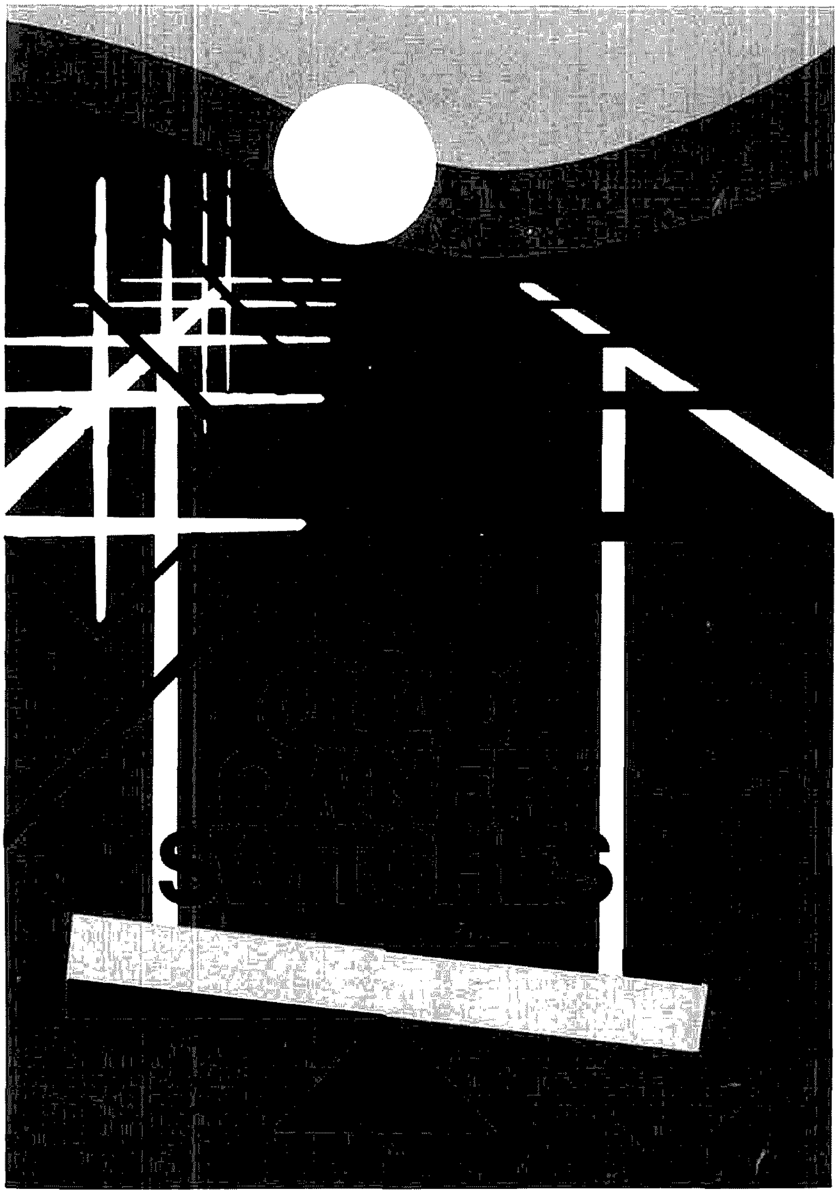
- improved cylindrical feedhorns
- the half-delta loop



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contents

Observation & Opinion

This month I present a guest editorial by one of our authors, Gary O'Neil, N3GO. Gary feels that operating procedures on 2-meter fm need to be changed and offers his suggestions. Alf Wilson, W6NIF, **editor**.

When the subject of Amateur Radio slips into a casual conversation, I spend a great deal of energy playing the role of recruiter. If successful enough at motivating an individual to join the family, I like to make his transition painless.

My latest recruit, although a licensed Amateur, had been inactive for some time. With a bit of persistence and a great deal of encouragement, I was able to pry him out of the closet and sell him on the virtues of 2-meter fm. After some shopping around, he was able to locate a nice compact 2-meter fm rig and carefully proceeded with the neat installation of his new acquisition into the family car.

Formerly an a-m operator on the high-frequency bands, but having some appreciation for channelized line-of-sight communications, he correctly deduced that a lengthy CQ would not be necessary. After listening to the limit of his patience, he decided to try "CQ, CQ CQ this is WA2— listening for any calls. What say somebody please?" He was answered immediately, welcomed to 2 meters, and quickly informed he was using incorrect procedure. On a few occasions that followed, he tried several variations of CQ with similar results until a neighborhood ham informed him, "You just don't call CQ on 2 meters!"

After a week or more of announcing he was listening on frequency to all of his available channels without response, he retreated back into the closet concluding that 2 meters is not used for talking. If current procedures were effective, I would be less likely to agree with him, but personal observations tend to support his comment. The "acceptable" procedure is not only ineffective, it is cold and uninviting.

The use of "listening on" or "monitoring" implies, "Call me if you have something important, otherwise I would rather not talk to anybody." Personally, I can justify only two reasons for calling a listener:

1. I know the person and I have something to discuss.

2. The person appears to have equipment trouble and should be made aware of it.

Another classic is, "QRZ the frequency?" If there truly is a stupid question, this one fits the category. Several hours of silence are broken by "QRZ . . . This is N2—I" This in turn is followed by — what else? Why, several hours of silence of course. Did that person really detect somebody calling him? The truth is, I am supposed to interpret the announcement as a CQ and give him a call — I think.

Clearly, if one announces he is listening, he is being self-contradictory; for at that moment, he is in fact talking and unable to receive. The obvious idea here is that the listeners wish to let other listeners know that they are not listening alone. Stated another way, they want everybody to hear them listening. On many occasions, I have heard stations respond by calling the listener after perhaps 30 seconds or so of inactivity. You guessed it — the listener got impatient and went off to listen somewhere else.

Collectively, these procedures tend to discourage and minimize 2-meter activity, which today is in competition with the TV cable industry. If we don't demonstrate our intentions to keep it active, we could very likely lose the 2-meter band. If it continues to appear we are going the way of CB, the FCC may decide to take early corrective action before the situation becomes uncontrollable. If the extreme sounds far-fetched (that is, the total loss of 2 meters), consider the "egg on the face" circumstances that CB has created for the FCC. How many times does one run out of gas before he starts watching the fuel gauge? The broadcast industry may or may not have a powerful lobbying organization, but why take the risk?

Aside from the legal ramifications, what is the problem with making Amateur Radio operating procedures at least spectrally universal? Why is calling CQ such a "no-no" on fm and shamefully sinful on a repeater especially? Why the concern with regard to the occasional use of a practical and informative operating procedure even though it differs from a habit created by a narrow view of the Amateur Radio disciplines?

Different modes, for convenience or efficiency, use formal operating procedures for very good reasons, such as high-volume traffic handling; but I fail to understand why a desire to communicate on 2 meters, in a manner similar to communications carried on in the high-frequency spectrum, needs to be initiated differently. Lengthy calls on 2 meters are in no way very useful and in the case of repeater operation, the procedure is even undesirable, but a short CQ can at the very least be tolerated.

Announce your desire to chat and assume listeners are present. CQ sounds like "seek you" and is perhaps key to its origin. More important, CQ invites conversation with newcomers and may just open a lot of doors. The use of abbreviations, Q-signals and slang creates the impression of a clique organization closed to outsiders. The image that 2 meters exhibits today discourages more than encourages, and I for one am bewildered by how it all began.

Lately, when I am coaxed into a ham radio demonstration, I hide my 2-meter rig, tune up on 40 and introduce my new recruits to some good-old-fashioned ham radio hospitality. When they are just about hooked, I take them out to the car, key up the local autopatch, and call their family to encourage their support. Then I immediately shut off the rig and send them home. If I ever happen to hear them calling CQ on the local machine, we will likely have a very nice chat. When we finally sign, they will never know that they goofed.

Gary O'Neil, N3GO

comments

one-wavelength versus full-wave

Dear HR:

Several correspondents have indicated an error in my January, 1982, article, "A Neglected Antenna for 40 and 80 Meters."

There can be a difference between a one-wavelength and a full-wave antenna. The one-wavelength reference pattern in my article was taken from Fig. 2-47 of the thirteenth edition *ARRL Antenna Book*. The text does not qualify this pattern as that of a harmonic antenna or a full-wave antenna, although it should.

If the one-wavelength wire were end fed, it would then theoretically match the reference pattern. End feeding would cause currents on each end of a one-wavelength wire to be out of phase; the antenna would qualify as a full-wave antenna and therefore nulls would appear broadside to the plane of the antenna. The center-fed, full-wavelength configuration will cause currents to flow in phase on both halves of the dipole. The result will be increased radiation from the sides of the antenna with the minimum lobe at the ends, and not as my reference pattern shows.

Using half-wave attachments to the open-wire feedline and selecting the proper impedance as I have shown in my article is still a good idea for maintaining a near omni-pattern.

I have written to the ARRL asking that the full-wave pattern (Fig. 2-47) be further qualified in the text and identified as that associated with a harmonic antenna. I understand that a new edition of the *Antenna Book* is in process.

Warren U. Amfahr, WØWL
Des Moines, Iowa

cheapie coax

Dear HR:

Gary O'Neil's article on traps in the October, 1981, issue of *ham radio*, page 10, was the answer to one of my antenna problems. I made a pair of 7-MHz traps to add to a 40-meter antenna for temporary or emergency use so it could be used on 40 or 80.

One of the other hams at work said he needed some traps for an antenna he wanted to build, so I took Gary's article to work for him to read at lunch. Several days later he said he'd made a pair of traps for 10 meters and they worked well.

Then he made a pair for 20, and crazy things started happening. One trap grid-dipped at 14 MHz and the other at 16 MHz. Investigation revealed that the 16-MHz trap was wound with a scrap of cheapie grade coax that had about 55 to 60 percent coverage by the outer conductor. The trap was rewound with a piece of good grade coax and it dipped at 14 MHz. Cheapie coax may be good for some things, but for traps, no cotton-pickin' way.

Wayne Stump, WB4AHZ
Lake Worth, Florida

good night!

Dear HR:

I'd like to respond to the comments of W6BQD in the January issue. The gentleman should recall the Biblical parable about attending to the beam in one's own eye before worrying about the dust mote in someone else's. For example, the best insult he could come up with for hams who like amusing phonetics is to liken them to folks from the "CB bands." The phrase is just as silly, grammatically, as 73s: it means Citizen Band bands.

While cute phonetics can easily be a problem for DX work, they shouldn't be for native speakers of English. Moreover, the clean ones are a lot easier to remember. For example, who could forget Under Forbidden Skies? Try it in standard phonetics. I don't know about low-band voice, but these memory aids are very common on 2 meters — and an awful lot of 2-meter ops, including myself, have never used a CB.

I think the FCC's objection to the use of Q signals on voice should also extend to the use of 73 — even though I use it myself, as well as a very common Q signal or two. The philosophy is the same: these were intended as abbreviations in CW work. There are some hams who don't know all of the Q signals, and (according to W6BQD) there are quite a few who don't know how to use the numbers right. Maybe we should all try *good night* for a change. It takes no more time to say, and it's a lot friendlier.

Phyllis M. Gilmore, KA6NFD
Colton, California

the other guy

Dear HR:

Your request to appeal to Chairman Fowler to "seek a relaxation of the projected cuts" is not, I hope, typical of all Amateurs.

We have requested reduction of government spending and government controls — but some people think it should be for the "other guys," and not where it affects "me."

As Amateurs, we should step in and offer our help to replace the services that the government will no longer provide. We probably can do it better and at less expense.

John Waterhouse, KA2GXS
East Aurora, New York

presstop

CHICAGO AMATEURS HAVE WON AN ANTENNA RESTRICTION FIGHT. A new ordinance would have permitted the installation of radio communications towers and satellite receiving dishes only as part of a "planned unit development" and would have required a special use permit as well. There are no current height limitations in that city covering Amateur installations, but had local hams not acted quickly, the ordinance could have meant a sudden death to new Amateur growth there, as well as having been a bad precedent which other cities might have copied.

Chicago Hams Quickly Organized under attorney Jim O'Connell, W9WU. They deluged their aldermen with telephone calls and letters, and on February 25th, O'Connell appeared at a City Council meeting. Near the close of that hearing an amendment was introduced, by the bill's original sponsor, which would exempt antennas and towers erected by federally licensed Amateur Radio operators from the ordinance proposal. O'Connell felt that Amateur Radio would probably receive the needed exemption.

TRANSMITTERS CAUSING INTERFERENCE IN THE 440-MHz REGION have been T-Hunted down by Santa Barbara, California, Amateurs. These devices, which may be either locators for off-shore oil drilling or "sounders" for oil exploration, were noted to cause RFI as far as 60 miles away. At least one of these transmitters was found on a U.S. Coast and Geodetic Survey concrete benchmark along the Southern California coastline, completely unattended. Some Amateurs feel these devices may pose a public safety hazard in addition to disrupting UHF communications.

Another Site, 30 miles from the first, was discovered quite by accident. This time, however, a frequency near 1.6 MHz was being used. Both "boxes" bore labels written in French, and each appeared to transmit digital data signals in two distinct modes. Measurements made by Amateurs also indicated these units produce spurious radiation in the 980-MHz region when switching modes.

What Is Not Known is to whom these units belong and what purpose they serve. The FCC has reportedly been informed of their existence. At least one unverified rumor claims these are but two of several such devices that will eventually run the length of both coastlines.

A ONE TIME EXCEPTION IS BEING MADE BY THE FCC regarding the renewal of club and military recreation station licenses. If you held such a license and it expired between March 11, 1977, and July 14, 1980, you can file for renewal before June 1, 1982, and have the request granted. Not included are repeater WR prefix callsigns, even if one was your club's call. As far as the FCC is concerned, WR callsigns for repeaters is a dead issue.

THE COMMISSION HAS DENIED a Petition for Reconsideration on its recent relaxation of the Amateur identification rules (P.R. Docket 80-136). The petitioner wanted a change in the wording of the new I.D. rules but the FCC ordered the new rules to stand as implemented. Also denied were RM-3137, which would have raised the power limits on parts of the 2-meter and 3/4-meter bands up to 2 kilowatts dc (in order to encourage more EME communications); and RM-3181, a proposal to reduce legal power limits of hf radiotelegraphy from 1 kilowatt to 250 watts.

A NOTICE OF PROPOSED RULE MAKING AND A NOTICE OF INQUIRY concerning the expansion of radiotelephony on the hf bands has been issued by the Commission. P.R. Docket 82-83 specifically addresses radiotelephone expansion on 20 meters, while the NOI deals with methods to be used to implement such an expansion, along with the question of additional phone expansion throughout the hf spectrum. The FCC did note that there had been seven petitions in regard to the subject, and that while all were in general agreement concerning the 20-meter proposal, there was a wide divergence of views about other hf phone allocations. The comment cutoff date is July 1st, with reply comments due August 2nd.

REGION I OF THE IARU HAS ALREADY FILED IN OPPOSITION to the ARRL proposal for expansion of U.S. radiotelephone privileges below 14.2 MHz, stating that permitting U.S. Amateurs (who would be running high power and directional antennas) into that spectrum would adversely affect the operation of foreign hams who run low power and very basic equipment. They also noted the decline in sunspot activity which in turn is leading many Amateurs away from 15 and 10 meters and onto 20. Region I feels that an influx of high-power U.S. stations could make Amateur operations in other parts of the world impossible, thus causing some to move their phone operations into the CW segment of the band. The shared use of portions of 20 meters by some European government and fixed services was noted as well.

ORBITAL SCHEDULES for Oscar 8 and for the UOSAT (Oscar 9) are available from ARRL headquarters for an SASE with "one unit of first-class postage attached." Send your request to the Club and Training Department, ARRL, 225 Main St., Newington, CT 06111.

a quad owner switches

Which is the better antenna, quad or Yagi? Read this dialogue to find out why a well-known ham switched to Yagis after using a quad for years.

Thousands of words have been published about the relative merits of cubical quads and Yagi antennas, and probably millions of hours have been spent in on-the-air debates of the matter.

Quad proponents claim their square-shaped, three-dimensional antennas have more gain than Yagis do — perhaps as much as 2 dB more. To support their contention, they point to various studies of the two antenna types. But on the other hand, Yagi boosters claim there is little or no difference in the performance of the two antenna types — and they can point to research supporting their contentions.

This article will never settle such a long-standing controversy, but it does tell an interesting story about the experiences of one ham who became frustrated with his quad and switched to Yagis. Probably lots of people have become frustrated and replaced one kind of antenna with another, but this ham took the trouble to actually measure the gain of his old and new antennas under controlled conditions. What he learned should be of interest to others who want a big signal but are limited to a single tower on a city lot.

Our story is about Dave Bell, W6AQ, the motion picture producer who made "The Ham's Wide World," "Moving Up to Amateur Radio," and most recently "The World of Amateur Radio." An avid DXer, he installed a large multi-element quad on a 70-foot self-supporting tower at his Hollywood Hills home. The quad had a 27-foot boom, with three elements on 20 meters, four elements on 15, and five elements on 10. The quad design is a popular one that has appeared in the *ARRL Handbook* and *ARRL Antenna Book* for many years.

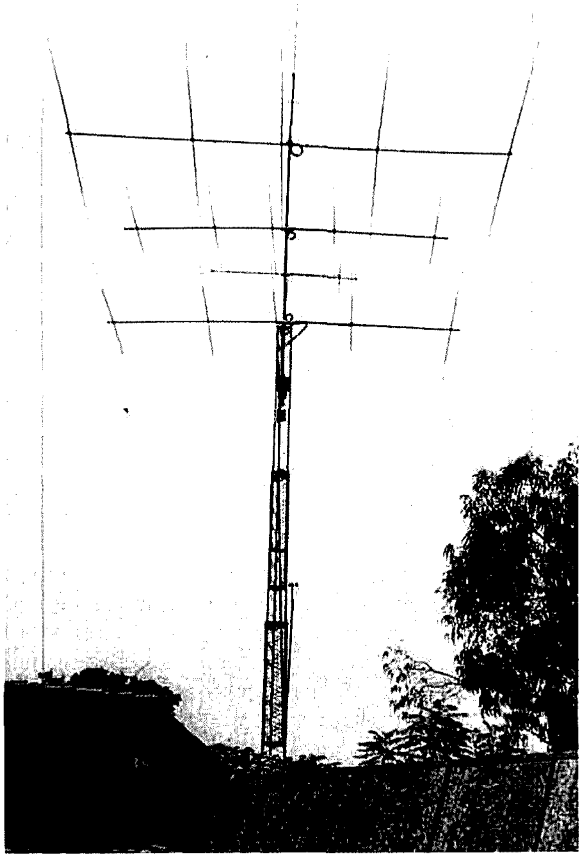
Based on the often-quoted finding that a quad delivers the gain of a Yagi 1.8 times its boom length,[1] Dave was hoping to come out even with nearby DXers using Yagis up to, say, 48 feet long. But years of slugging it out in the pileups convinced him the quad just wasn't delivering that kind of gain. Sometimes, in fact, the big quad came out second best to small trap tribanders in the Los Angeles area:

The painful decision to scrap the quad actually

By Wayne Overbeck, N6NB, and **Dave Bell, W6AQ,** c/o California State University, Fullerton, Department of Communications, Fullerton, California 92634

came when my friend Bernie, W6PJX, took me in a long-path pileup into Europe. He's using a TH3 (a three-element tribander) with a reflector that tilts as if a 60-pound owl crash-landed on it. That indignity, plus being regularly bested on 20 by TH6s (also tri-band Yagis), forced me to hear what my pals had been telling me. My razor sharp mind started counting alternatives to the quad — alternatives that would fit on a 50-foot-wide lot. Let's see, there's the Yagi and...

A major manufacturer (Hy-Gain) had just announced a new line of five-element monoband Yagis with relatively short booms — antennas that could be stacked on Dave's existing tower without creating an excessive windload or a neighborhood revolution. A "Christmas tree" stack of these close-spaced Yagis is about as big an array as most Amateurs on a city lot could swing, Dave felt. So he ordered the new Yagis.



The new stack of monoband Yagis at W6AQ; they work great, but don't look up at them from the patio below! (See text.)

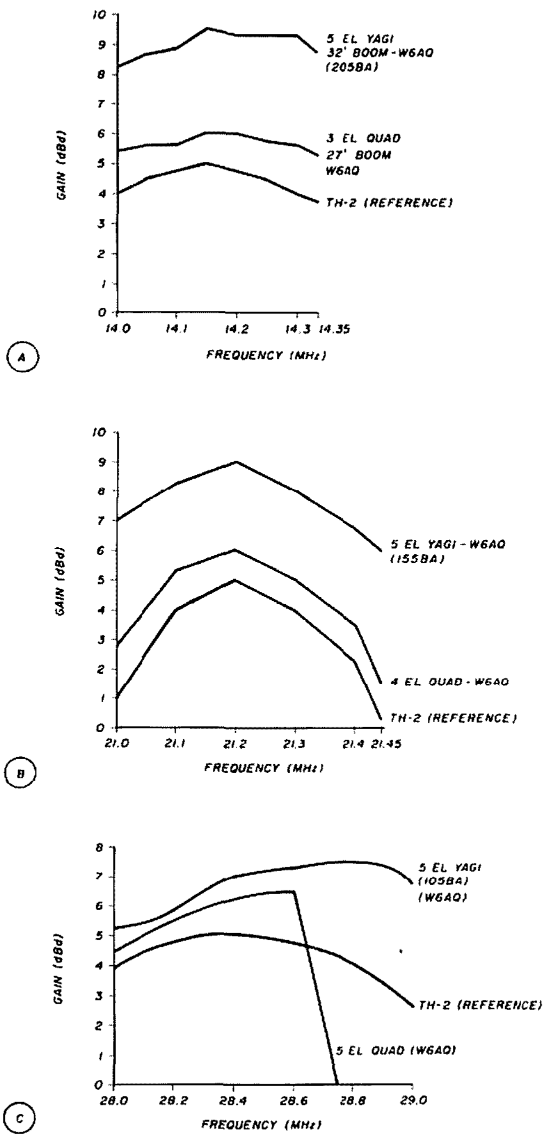


fig. 1. Test results for 20, 15, and 10 meters (A, B, and C respectively). Data confirms W6AQ's on-the-air experiences.

the gain measurements

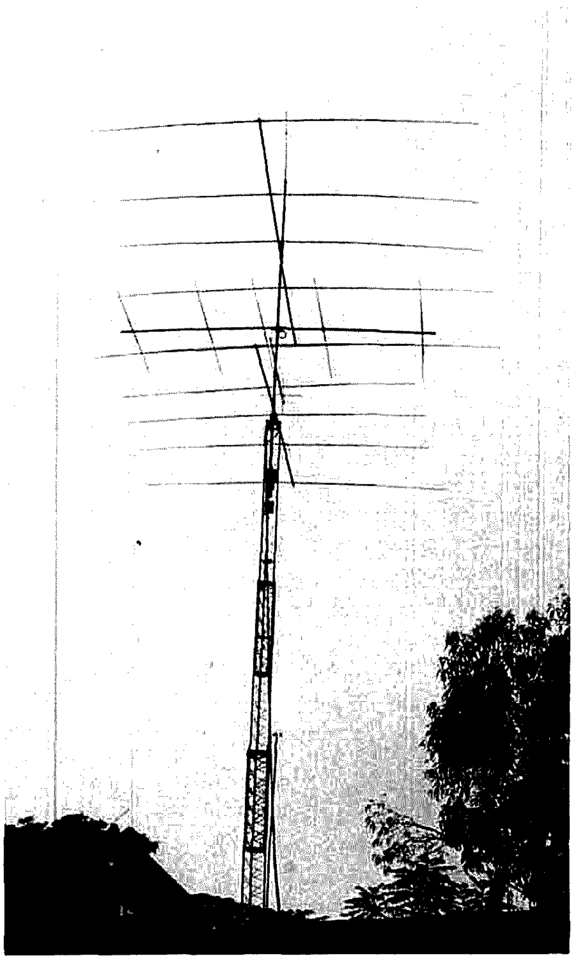
Before Dave took down the big quad, we measured its forward gain on all three bands, using the techniques described in two previous articles.[2, 3] Briefly, the technique involved placing a reference antenna (a small two-element tribander) atop a trailer-mounted 70-foot tower beside Dave's antennas.

In these tests, a station about 20 miles away (but

clearly line of sight from Dave's hilltop location) provided a steady signal for gain comparisons between the quad and the reference antenna at various points across the 10, 15, and 20 meter bands. The relative gain of the two antennas was measured and recorded, using a Drake R-4C receiver with the AGC turned off and an audio decibel meter reading the output.

The quad was then taken down and replaced with the three close-spaced Yagis. The 20-meter beam was placed on top, with the 10 in the middle and 15 on the bottom of the stack, using 7.5 foot vertical separation between antennas:

The 20-meter Yagi is on the top of my stack for two reasons: 1) It's the first one Hy-Gain got into production and consequently the first one I put up; 2) The twenty ought to be the farthest from the ground, I think, though I get kidded about it. I called Kit Kitterer at Hy-Gain to ask his opinion of the twenty on top and he said that was the obvious place for it but their ads showed it in typical Christmas tree fashion because that arrangement was more esthetically pleasing. (I know it's heresy, but I don't think antennas are measurable in terms of esthetics.) The 10-meter antenna was next to arrive, so it went on the tower next, and finally the 15-meter beam arrived and there you have it.



The final stacking arrangement, with the 10-meter Yagi at a right angle to the others. This configuration produced more gain on 10 meters than the in-line arrangement, but is it really 2-dB down in beauty?

Even discounting any new antenna owner's anticipation of better results, I got and am getting far better on-the-air reports with the new Yagis.

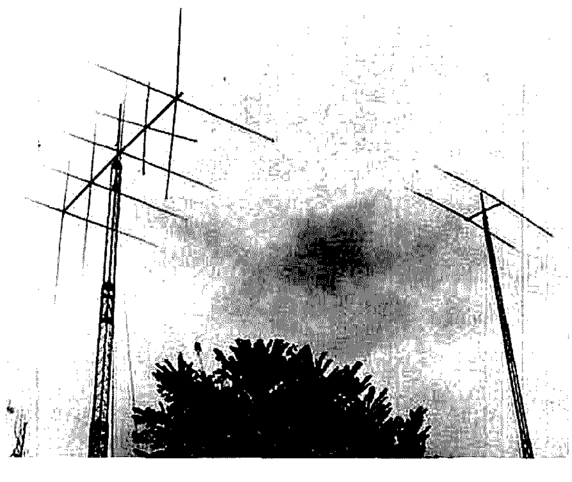
There is only one complaint I can voice about the Hy-Gain stackables, as they call them. It is somewhat unsanitary to sit beneath them inasmuch as the birds, who never cared for my quad, are absolutely in love with all of those straight branches I put up for them. When walking beneath my Christmas tree, the best advice is, don't look up.

To verify Dave's on-the-air observations about the relative superiority of the new Yagis, we repeated the gain measurements, using exactly the same hardware and test procedure as with the quad. The portable tower was positioned in the same place and the same reference antenna was used, with the same station providing the test signal again. The reference antenna was even stored indoors during the interval between tests to assure that its performance would not deteriorate. The only thing different during these second tests was that a stack of Yagis was now on Dave's tower where the big quad had been. Dave even measured the new coaxial cables against the old:

A friend of mine came upon a lot of new RG-213 at a bargain, so I of course bought some to use with the new Yagis. When I realized that it would present a variable in Wayne's measurements, I measured its loss. When the four-year-old RG-8 came off the quads, I measured its loss too. Predictably, the 213 and RG-8 were identical at 28 MHz. The old coax is feeding a pair of two-meter antennas and my low band wires now.

To standardize the height of each new antenna at the 70-foot boom height used in the prior tests, Dave's tower was lowered for the tests of the 20- and 10-meter Yagis, which were 15 and 7.5 feet, respectively, up the mast from the top of the tower. Thus each Yagi was measured at exactly the same height as the old quad.

The results of the test, shown in **fig. 1**, were no surprise to Dave because of his on-the-air experiences, but the extent to which the Yagis outperformed a quad of about the same size surprised everyone else.



Replica of W6AQ's quad set up for testing at N6NB. After careful pruning, its gain improved but still didn't match the gain of several Yagis that were tested on the same tower.

the results

At every single frequency where a reading was taken, the Yagis were superior to the quad, often dramatically so. On both 15 and 20 meters, the Yagis were typically 3 dB better than the quad. That makes as much difference as doubling the transmitter power output!

The 10-meter Yagi also outperformed the quad, but by a lesser margin, apparently due to interaction problems. The 10-meter Yagi's gain fell considerably below the manufacturer's specifications, while the measured gain of the 15- and 20-meter arrays was close to specifications (thus lending credibility to those specifications, especially since the original prototypes were undoubtedly measured in the clear; that is, unstacked). But we wondered if the 10-meter beam was performing as it should, even though it exhibited a good SWR and nearly 30 dB of front-to-back ratio.

To find out, we rotated the 10-meter beam 90 degrees on the mast, turning its boom to a right angle in relation to the 15- and 20-meter booms. Remeasuring the gain without changing anything else, we found that the 10-meter antenna's gain had increased almost exactly 1 dB all across the band. Obviously, there were — and probably still are — interaction problems on 10.

To show you that the demon antenna expert is really just a pussycat, after measuring 1 dB or so better gain when the 10-meter beam was swung 90 degrees, Wayne suggested we swing it back into line!

I couldn't believe it! "It'll gain at least 2 dB in beauty," he explained. "Humbug," said I, and the 10-meter beam remained pointed off in its own direction, louder and prouder.

Another surprising thing we discovered in the 10-meter tests was that the quad's gain abruptly fell off above 28.7 MHz. Up to that frequency, the quad's gain was close to that of the Yagi and it exhibited a seemingly normal front-to-back ratio (about 20 dB). But suddenly the quad's gain plunged downward; its gain was nearly 15 dB below the reference tribander at 29.0 MHz! However, rotating the quad revealed an incredible phenomenon: the quad had nearly 20-dB *back-to-front* ratio above 29.0 MHz. The reflector had ceased to function as such, and the first director had become a reflector!

My face is red, but I have my excuses in place. First of all, ten was basically deserted during the four-year period that I used the quad. Second, I rarely operate above 28.7. Third, my inherent laziness allows me to work stations "off the back" if signal levels are mutually acceptable.

Little did I know that in my case "off the back" could have been better than "off the front" since I never observed that curiosity. Had I done so I probably would have chalked it up as a long-path contact, though I doubt there are many long-path openings between L. A. and Detroit.

Frankly, I can't imagine the cause of the quad's not knowing which end was which unless mother nature took her toll on my solder joints and gremlin capacitances hexed the poor old wire monster.

repeating the experiment

Dave's quad was a faithful reproduction of a very popular design — one that has appeared in many editions of the ARRL publications. Several well-known DXers with years of antenna-building experience had helped build Dave's quad. Did they incorrectly measure the elements on all bands? Or had old age set in? Was there really something wrong with Dave's quad, or could this be viewed as an indictment of quads in general?

As we looked at the data, it was apparent Dave's quad wasn't performing as well as would be expected on any band — not just on 10 meters where it abruptly developed backward directivity halfway up the band. And it seems unlikely the elements were mismeasured on all three bands.

Then was the quad badly mistuned? Perhaps, but nowhere does the *ARRL Handbook* description of the antenna say the dimensions given may not work, and that each antenna must be individually tuned if it is to work correctly. If every cubical quad must be individually tuned after it is installed, whereas Yagis can be simply cut to published dimensions, that would be a real disadvantage of quad antennas.

To explore some of these questions, we built another cubical quad identical to Dave's, very care-

fully cutting the elements to the dimensions given in the *ARRL Handbook*. We put it atop the trailer-mounted 70-foot tower and placed the reference TH-2 beside it on another 70-foot tower. Since a variety of other antennas had already been measured in this test configuration, we could compare this new quad against a variety of different Yagis, both monobanders and tribanders.

When we put up the replica of Dave's quad, it was not resonant anywhere near the proper place in any band. In all instances, the elements turned out to be much too long in our installation, resulting in backward directivity much like that observed on 10 meters with Dave's quad. Using SWR plots made with the antenna at its full height as an indicator of resonance, we gradually shortened each driven element until it was resonant near the middle of the appropriate band.

Next, we calculated the *percentage* longer or shorter that the reflectors and directors were supposed to be with respect to the driven elements, using the *Handbook* dimensions. The result was an antenna that faithfully reproduced the *design concept* of the *Handbook* quad: the reflectors and directors were the same percentage longer and shorter than the driven elements as in the original design, although the actual dimensions of all the elements were much shorter than those given in the *Handbook*. In working with wire antennas, we have often found that the correct dimensions for a given frequency may vary somewhat from those published, depending on the size and type of wire, whether the wire is bare or covered, etc.

Once we had completed these adjustments, we got good results — but not as good as some cubical quad devotees would predict. Across the 20-meter band, the quad averaged about 1 dB less gain than a similar-size four-element Yagi that we had tested on the same 70-foot tower in the same place, using the same feedline and the same TH-2 as a reference (with the TH-2 also in the same place). On 15, the quad was consistently 2 dB down from a five-element Yagi we'd tested on the same tower. And on 10, the quad was about 0.5 dB down from a five-element Yagi — until we reached the frequency where the quad reversed its directivity. At that point, its gain dropped many, many dB below the Yagi's. In both on-the-air tests using skip signals and local measurements of directly radiated signals, we found the quad to be an excellent triband antenna, but no match for monoband Yagis of the same size.

Ah, you say, but this was a comparison of a triband quad against monoband Yagis and therefore unfair to the quad. To find out how well the quad would work as a monobander with elements for just one band, we tested it as a five-element 10-meter quad (that is, with the 15- and 20-meter elements removed). The extra elements made virtually no difference: if anything, the quad was a little better on 10 meters with the 15- and 20-meter elements than without them, altough the resonant frequency was a *little lower with the extra elements. Even as a monobander*, the quad still didn't match the gain of a similar size Yagi.

conclusion

What does all of this prove? Well, it suggests that Dave's quad wasn't working quite as well as it should have been. With patience and pruning, it could have been made to work a little better, but probably not as well as his new Yagi stack.

And that, really, was what Dave's experiment was all about: he wanted to know which antenna system is the best bet for someone who lives on a typical city-size lot as he does. Monster long-boom antennas (either quads or Yagis) were out of the question, but a stack of Yagis with relatively short booms was feasible — as was a multi-element quad. And Dave found out the stack of Yagis was the better performer.

Shortly after we finished testing the second version of the *Handbook* quad, Jim Lawson's article based on computer analyses of quads and Yagis appeared in *ham radio*.[4] Lawson concluded that an ideal long-boom quad might deliver up to half a dB more gain than a similar size Yagi, but that in the real world, optimizing a cubical quad may be so difficult as to make this theoretical gain advantage illusory. (Lawson also pointed out that tuning any big antenna near the ground is a sure way to guarantee that it will *not* be correctly tuned at its working height. If you want to optimize a quad, be prepared to repeatedly raise and lower it — or borrow someone's "cherry picker.")

Our field tests of quads and Yagis have produced much the same conclusion as Lawson's theoretical analyses. In years of measuring the gain of quads and Yagis, we have yet to find any long-boom quad in the real world that performs as well as an equal size Yagi.

We don't claim any of this settles the quads-versus-Yagis controversy for all time, but neither do we suggest that you try to hold your breath until Dave Bell switches back to a cubical quad!

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1. Lindsay, "Quads and Yagis," *QST*, May, 1968, page 11.
2. Wayne Overbeck, N6NB, "Measuring Antenna Gain with Amateur Methods," *QST*, October, 1977, page 11.
3. Wayne Overbeck, N6NB, "Quads and Yagis Revisited, *ham radio*, May, 1979, page 11.
4. James L. Lawson, W2PV, "Yagi Antenna Design: Quads and Quagis," *ham radio*, September, 1980, page 37.

ham radio

dipole antenna over sloping ground

Even slightly uneven ground beneath your antenna can have a big effect on the pattern

Charts in numerous publications show the elevation patterns of a horizontal dipole at various heights above ground. These patterns assume perfectly conducting *flat* ground. For horizontally polarized waves, the perfectly conducting ground is normally a good assumption. But for those who don't live over *flat* terrain, is the effect of uneven or sloping earth significant?

A friend who lives on a hill informed me that, of his three antennas at 35, 50, and 100 feet (10.6, 15, and 30.5 meters) the lower-height antenna gave consistently better results on 10-meter DX. I therefore decided to investigate the effects of sloping ground under an antenna. The results are quite interesting.

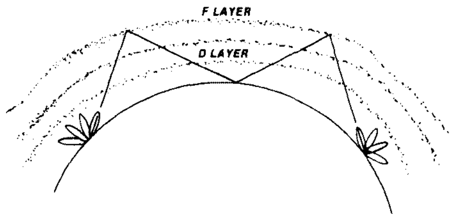

fig. 1. Dipole located at a height above ground which results in an elevation pattern that matches the arrival wave angle.

optimum wave angle

The ideal antenna system will be optimized in performance by placing the antenna at a height above the ground that will match the vertical elevation angle to that of the propagation wave, as in **fig. 1**. It has been found that the vertical wave angle for a New Jersey-to-London path is inversely proportional to frequency[1] (see **table 1**). Note that the mean vertical wave angle is 22 degrees on 40 meters, 11 degrees on 20 meters, 7 degrees on 15 meters, and 5 degrees on 10 meters.

A possible cause for higher vertical wave angles being useful at lower frequencies is D-layer absorption. This absorption, which is more significant at lower frequencies, increases at lower vertical wave angles because the signal travels further within the D layer. Since D-layer absorption is a function of ionization level, the wave on low frequencies may favor higher angles in the daytime. Also, for a given ionization-layer height, shorter-range communications involve higher vertical wave angles. Lawson[2] discusses useful wave angles. Good data on optimum vertical wave angles for DX Amateur communications for varying diurnal, seasonal, and solar cycles and frequencies is sorely needed.

dipole over flat ground

To find the vertical wave angle of a horizontal dipole over flat ground, see **fig. 2**. The dipole at height, h, above the ground has an image antenna an equal distance below ground. The reflected wave may be considered as emanating from this image antenna. The reflection from ground of a horizontally polarized wave also introduces an additional 180-degree phase shift. The incoming direct and reflected waves arrive at points A and B in the same phase, since they are both on the advancing plane-wave front. The reflected wave must advance the addi-

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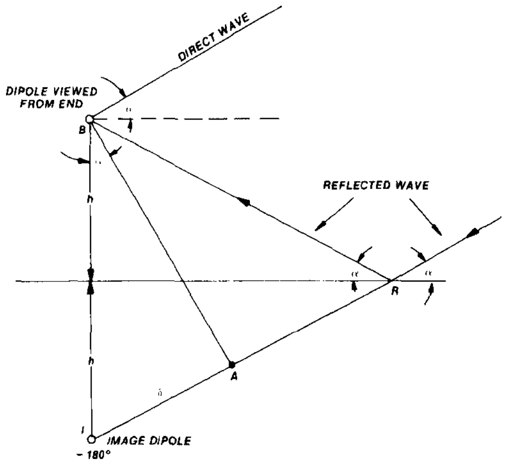

fig. 2. Dipole at height, h, above ground has an image antenna an equal distance below ground. The reflected wave may be considered as emanating from the image dipole starting with a phase shift of 180 degrees.

tional distance from A to the image antenna and therefore suffers additional phase shift plus the 180-degree reflection. Therefore, the two waves *don't arrive in phase*.

There are certain elevation angles, α, for a given antenna height that will result in the extra path length, δ, being 180 degrees. This 180 degrees will add to the reflected 180-degree phase shift and result in the two waves adding in phase, which will cause a maximum in the elevation pattern. Additional maxima will occur when $\delta = 540$ *degrees*, *900 degrees*, *1260 degrees*, and so on. (For a mathematical derivation of this effect, refer to Appendix 1.) The total phase shift, Δ, is equal to $\delta + 180$ *degrees:*

$$\Delta = 2h \sin(\alpha) + 180^\circ \tag{1}$$

This equation can be solved for h in terms of Δ and α:

$$h = \frac{\Delta - 180^\circ}{2 \sin(\alpha)} \tag{2}$$

By setting $\Delta = 360$ *degrees* (first maximum of the pattern) and α equal to the optimum vertical wave angle for each frequency band, the optimum antenna height for each band can be determined.

When α from the measured data of the London-to-New Jersey path is used, an interesting result occurs. The heights for 40 through 10 meters are 240, 472, 738, and 1033 electrical degrees respectively. The electrical height, h, of the antenna may be converted to the physical height in feet, h_f, by the relationship

$$h_f = \left(\frac{h}{360}\right)\left(\frac{984}{f}\right) \tag{3}$$

where f is the frequency in megahertz. This results in optimum antenna heights of 94, 92, 96, and 101 feet (28.7, 28, 29, and 30.8 meters) for 40 through 10 meters respectively. The inherent uncertainties of the variables and the pattern width involved don't warrant specifying the height to the nearest foot, but the interesting fact is that heights of 90 to 100 feet match quite well useful wave angles for 40 through 10 meters.

dipole over tilted ground

A dipole over sloping ground is shown in **fig. 3**. The dipole is at a height, h, above the ground immediately below the antenna, at the base of a vertical supporting structure. The true electrical height, h_e, is slightly less and is the distance from the antenna at B to the ground along a line perpendicular to the ground.

The image antenna also lies on the perpendicular line at a distance h_e below ground. The first effect of tilted ground, therefore, is to lower the effective height of the antenna. This effect is rather small, however.

A large ground tilt of 11 degrees reduces the effective height of an antenna 100 feet (30.5 meters) high by only 1.8 feet (0.5 meter). A much more significant factor is the effect on the reflection angle at R of the ground tilt. For a mathematical derivation of the additional phase shift, Δ, refer to Appendix 2. The formula for phase shift is shown in **eq. 4**.

table 1. Arrival wave angle from England to the New Jersey coast (from reference 1).

frequency (MHz)	angle below which signals arrived 99% of the time (degrees)	angle above which signals arrived 50% of the time (degrees)	angle above which signals arrived 99% of the time (degrees)
7	35	22	10
14	17	11	6
21	12	7	4
28	9	5	3

$$\Delta = 2h \cos(\gamma) \sin(\alpha - \gamma) + 180^\circ \qquad (4)$$

Solving this equation for h in terms of Δ, α, and γ, we have

$$h = \frac{\Delta - 180^\circ}{2 \cos(\gamma) \sin(\alpha - \gamma)} \qquad (5)$$

Now consider what happens when even a small ground slope of +3 degrees exists. Using again the same wave angles of **table 1**, $\Delta = 360$ *degrees* for the first maximum; and solving for the optimum height, h, we have 108, 126, 168, and 252 feet (33, 38, 51, and 77 meters) for 40 through 10 meters. As can be seen, the effect of tilted ground is very significant. The effect on the lower frequencies is less pronounced because of the higher wave angles. The higher-frequency bands require that the antenna be much higher than when over flat terrain. The effect of a downward slope of 5 degrees, or $\gamma = -5$ *degrees* is also significant.

Optimum antenna heights are 78, 64, 56, and 51 feet (24, 20, 17, and 16 meters) for 40 through 10 meters. It seems that the combination of a location on a hill plus a high antenna can be detrimental: too much of a good thing.

patterns

Determining the elevation pattern of the dipole over ground from the phase shift of the reflected wave is straightforward. The direct wave is defined as 1 volt at 0 degrees, or $1\angle 0$ in polar form. The reflected wave is 1 volt at Δ degrees, or $1\angle\Delta$ in polar form. The total voltage resulting from both waves is then $1\angle 0 + 1\angle\Delta$. Converting each of these to rectangular form and adding, we have:

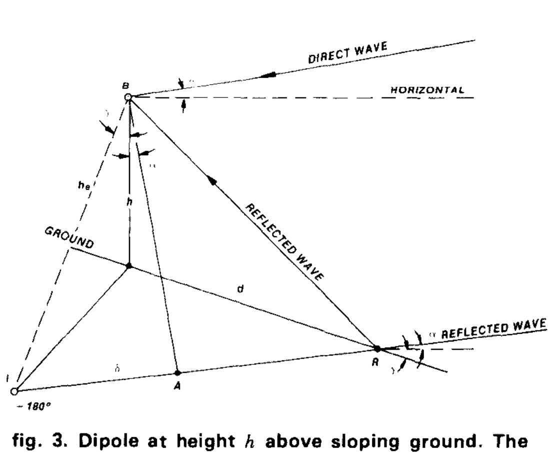

fig. 3. Dipole at height h above sloping ground. The slope of the ground, γ, is negative for ground below the horizon in the direction of propagation. The elevation wave angle, α, is still referenced to the horizon. The height is the length of a vertical supporting tower.

$$\begin{array}{rr} 1 & +j0 \\ \cos\Delta & +j\sin\Delta \\ \hline 1+\cos\Delta & +j\sin\Delta \end{array} \qquad (6)$$

and then converting back to polar form,

$$E = \sqrt{(1+\cos\Delta)^2 + \sin^2\Delta} \Big/ \tan^{-1}\left(\frac{\sin\Delta}{1+\cos\Delta}\right) \qquad (7)$$

The absolute magnitude of the total voltage

$$|E| = \sqrt{(1+\cos\Delta)^2 + \sin^2\Delta} \qquad (8)$$

may be rewritten

$$|E| = (\sqrt{2})(\sqrt{1+\cos\Delta}) \qquad (9)$$

The E-field (horizontal) pattern that results varies from a maximum of 2 to a minimum of zero as the direct and reflected waves add and cancel in phase.

To calculate the actual gain of a dipole over ground, the effects of the mutual impedance of the dipole and its image must be taken into account.[3] For antennas high above ground, this effect is small. The relative E-field patterns found by the previous procedure are not affected by the mutual impedances.

The elevation patterns of a dipole antenna at 95 feet (29 meters) over flat ground are given in **table 2**.* The first maximum of each is shown in **fig. 4**. Notice how well the patterns match the optimum

*In the following text, **tables 2, 3,** and **4** refer to computer printouts. Copies of these tables may be obtained by sending a self-addressed, stamped business size envelope to *ham radio*, Greenville, New Hampshire 03048.

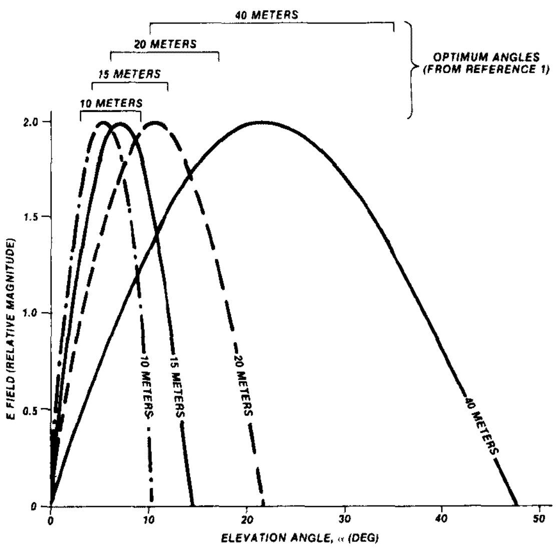

fig. 4. First maxima of the elevation pattern of a dipole 95 feet (29 meters) above flat ground for 40 through 10 meters. Notice how well the maxima match the optimum wave angles as shown in table 1.

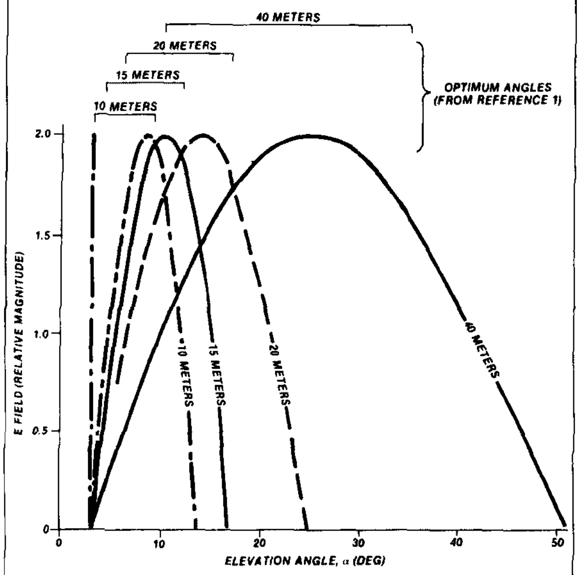

fig. 5. First maxima of the elevation pattern of a dipole 95 feet (29 meters) above ground with an upward slope of 3 degrees for 40 through 10 meters. Notice the misalignment of the maxima and the optimum wave angles, particularly at higher frequencies.

wave angle[1] on each band. The elevation patterns of a dipole 95 feet (29 meters) above ground for 40 through 10 meters (ground sloping *upward* 3 *degrees* toward the incoming wave) are given in **table** 3 and **fig.** 5 and in **table** 4 and **fig.** 6 over ground sloping downward −5 degrees. Notice the severe misalignment of the wave angle and the elevation pattern for both cases.

reflection point

The distance, d, from the base of the dipole's tower to the reflection point is

$$d = h\left[\frac{\cos\gamma}{\tan(\alpha-\gamma)} - \sin\gamma\right] \qquad \textbf{(10)}$$

This is closely approximated by the simpler relationship

$$d \approx \frac{h}{\tan(\alpha-\gamma)} \qquad \textbf{(11)}$$

where d and h are in the same units. For $h = 96\,feet$ (29 meters), α = the optimum angle for each band over level ground ($\gamma = 0$). For Amateur bands 40 through 10 meters, d equals 235, 489, 773, and 1086 feet (72, 149, 235.8, and 325.8 meters). The effect of ground tilt on the distance to the reflection point is most significant on the higher frequencies. For $\gamma = -5$ *degrees*, the reflection point moves in to 539 feet (164 meters) on 10 meters and 186 feet (56.7 meters) on 40 meters. In estimating the effects of sloping ground at your location, it's usually necessary to take into account the location of the reflection point. If, for example, your antenna is on a hill or in a valley of an extent less than the reflection-point distances involved, with flat ground beyond, *then* the net effect of the hill or valley will be to raise or lower the effective height of your antenna.*

Yagi antenna over tilted ground

An excellent treatment of Yagis over flat ground is given by Lawson.[2] He also discusses the tilted Yagi over flat ground. The case of a horizontal Yagi (perpendicular to a vertical tower) over sloping *ground is* similar to a dipole over sloping ground. The largest effect of a Yagi in this case is that the magnitude of the pattern lobes is reduced at higher elevation angles. A high-gain Yagi will also lower, very slightly, the angle of the maxima.

Tilted ground under a Yagi will also fill in the nulls

*A program for RPN calculators is available that gives the E-field in increments of 2 degrees for the elevation pattern of a dipole over flat or tilted terrain. Send a self-addressed, stamped business size envelope to *ham radio*, Greenville, New Hampshire 03048, for a copy.

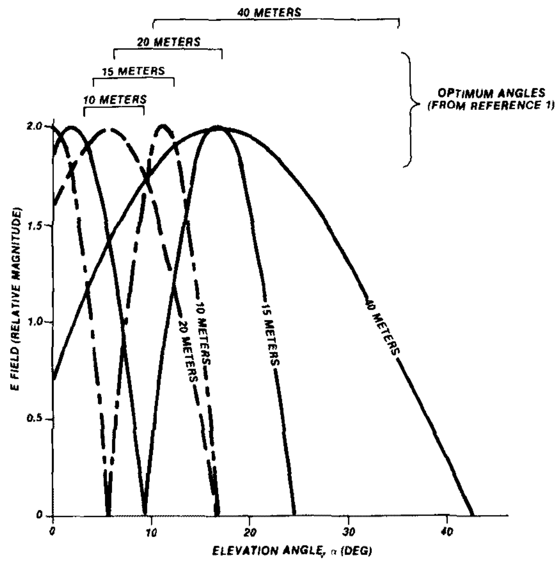

fig. 6. Low-angle maxima of the elevation pattern of a dipole 95 feet (29 meters) above ground with a downward slope of −5 degrees for 40 through 10 meters. Notice on 10 meters the misalignment is so severe as to actually have a null in the pattern at the desired wave angles.

in the elevation pattern, much like a tilted Yagi over flat earth. To understand why this is so, refer to **fig. 3**. Note that the direct and reflected waves arrive at the antenna at point B at different angles. Therefore, the free-space elevation pattern of the Yagi will reduce somewhat the voltage of the reflected wave impressed upon the terminals of the Yagi as compared with that impressed by the direct wave. The two waves *do not* have equal amplitudes. Therefore, even when phase cancellation occurs, complete cancellation of the voltage *does not* occur. This effect is most pronounced on high-gain Yagis with fairly large ground slopes.

acknowledgment

I'd like to thank John Hollis, Jr., WA4QLL, for writing the computer programs and preparing the tables of E-field elevation patterns. John and I have had many interesting conversations on antennas over sloping ground and we have run over-the-air tests investigating this effect.

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2. Jim Lawson, "Yagi Antenna Design: Ground or Earth Effects," *ham radio*, October, 1980, pages 29-37.
3. J.D. Kraus, *Antennas*, McGraw Hill, 1950, page 305.

appendix 1

Refer to **fig. 2**. Since A and B lie on the plane wave front of the incoming wave, BAI is a right triangle. Angle IBA is equal to the elevation angle. The hypotenuse of the right triangle is $2h$. Therefore,

$$\sin(\alpha) = \frac{\delta}{2h} \quad \textbf{(A1)}$$

and then

$$\delta = 2h \sin(\alpha) \quad \textbf{(A2)}$$

The total phase shift must include the reflection 180 degrees, so

$$\Delta = 2h \sin(\alpha) + 180^\circ \quad \textbf{(A3)}$$

appendix 2

Refer to **fig. 3**. Again BAI is a right triangle. Angle IBA is equal to α plus γ. Since γ was chosen as negative for the downtilt configuration of **fig. 3**,

$$\text{angle } IBA = \alpha - \gamma \quad \textbf{(B1)}$$

The effective height of the antenna, h_e, is

$$h_e = h \cos(\gamma) \quad \textbf{(B2)}$$

therefore,

$$\delta = 2h \cos(\gamma) \sin(\alpha - \gamma) \quad \textbf{(B3)}$$

The total phase shift is

$$\Delta = 2h \cos(\gamma) \sin(\alpha - \gamma) + 180^\circ \quad \textbf{(B4)}$$

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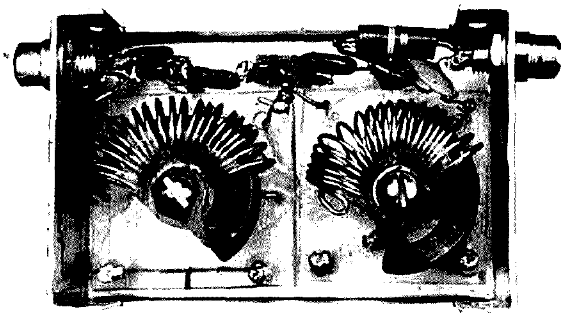

inductance-tuned lowpass antenna matching unit

An experimental design for low-power transmitters

This article is meant to raise more questions than it answers, because it is about a subject where many questions still need to be answered.

It's interesting to review the history of antenna matching in the design of manufactured final amplifiers. I remember working an old Johnson Viking Invader into loads with SWRs as great as 5:1. Later vacuum-tube equipment was good for loads with SWRs up to only 2:1. But note what all the manufacturers are selling us now: solid-state finals with no panel controls. Great — but suppose the load doesn't look exactly like 50-ohms resistive? You're putting out less power, or the safety relay opens up altogether. So obviously you may need an outboard gadget for your compact rig: an antenna-matching network, which is available from numerous manufacturers, usually called a "transmatch."

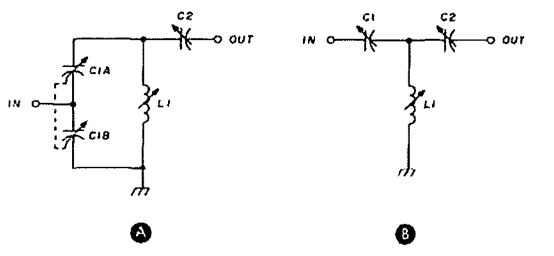

fig. 1. High-pass transmatches.

These commercial transmatches are usually copies or modifications of the original circuit by W1ICP[1] as "The Ultimate Transmatch." Its circuit is shown in **fig. 1a**. Variable capacitors C1a and C1b are ganged. Amateurs soon discovered that C1b did not contribute to a match: the basic circuit of **fig. 1B** works just as well. Virtually all rf matching networks except transformers are also filters, however, which may be lowpass, bandpass, or highpass configurations. It's evident that the circuit of **fig. 1B** is a highpass T net-

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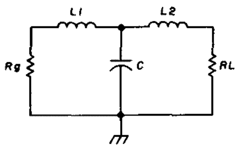

fig. 2. Lowpass T network.

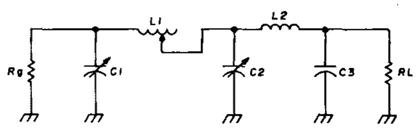

fig. 3. Capacitor-tuned pi-L network.

work. Such a circuit is just the opposite of what's needed to attenuate harmonics.[2]

With the prevalent highpass form of transmatch, one must rely for harmonic suppression entirely upon the lowpass untuned matching network built into the commercially manufactured transmitter's final amplifier, which is usually designed for a 50-ohm resistive load. Obviously, harmonics would be better suppressed if one could use a lowpass T as in **fig. 2.**

There is a practical problem of how to tune lowpass networks. In the original transmatch of **fig. 1,** most of the tuning is done by variable capacitors C1 and C2. When the mismatch is not very great, inductor L1 is varied only for band changing, taps and a rotary switch with grounded arm being used. Now in the case of the lowpass T, this design has been unpopular because of the difficulty of tuning inductors continuously over a wide range of values,[3] or even of step-switching them at a high-voltage point above ground, which makes construction more difficult. These facts apply even in the case of the old-fashioned conventional lowpass pi network. However, JA6GW[4] has succeed in building a lowpass T high-power antenna-matching network to handle SWRs of up to 3:1 on three bands. Referring to **fig. 2,** C is continuously tuned, L1 is untuned and L2 is step tuned.

lowpass experimental network

My objective was to design a lowpass tuned network for a QRP (low-power) portable transmitter that would match antennas under the variety of SWR conditions I was to meet, and, at the same time, would suppress unwanted frequencies sufficiently to *eliminate the need for the fixed-tuned 50-ohm transmitter output network altogether.* My first design was a capacitor-tuned pi, followed by a fixed-L network for additional harmonic suppression, as in **fig. 3.** To keep the equipment small I used for C1 and C2 small imported 365-pF variable capacitors with polystyrene dielectric. Such capacitors proved to be relatively unsatisfactory because of contact jitter, especially under salt-air conditions.[5]

The obvious direction to move lay in using something like a lowpass T and tuning L1 and L2 (**fig. 2**). I had previously simplified the half-toroid powdered-iron-vane tuned inductor made by K1KLO and described by W1CER in a low-power version of the original transmatch.[6,7] The photograph in the 1976 article shows that K1KLO apparently cemented one cut edge of his half-toroid core to a flat piece of metal, which was joined to the shaft collar. This was the core's sole support. As the shaft was turned for tuning, the core penetrated by varying amounts into the half-toroid coil.

The main advantage of K1KLO's design is that, with its thin support, the core can be turned almost 180 degrees. The disadvantage is that the support end of the core must be machined precisely at right angles to its plane. Thus the designer is pretty well limited to the use of powdered iron cores. This limitation is satisfactory for oscillator design, because temperature drift of permeability is so much worse in ferrite cores. However, for tuned-radio-frequency stages in receivers, the temperature change of permeability is usually of little importance, so that one can take advantage of the greater tuning range afforded by inserting ferrite cores into a coil. The same is true of tuned inductors in transmitter-matching networks, except for the important fact that a ferrite core saturates easily. Core problems are discussed further at the end of the article.

variable inductor

My simplified design of a variable inductance[3] entails the use of a flat sickle with central hub made from fiberglass-epoxy resin circuit board with the copper etched off. The half-toroid core is glued to the blade part of the sickle, and the hub is screwed to the end of the tuning shaft. With this technique the ends of the toroid do not have to be machined, thus making it possible to use ferrites.

Contrary to popular belief, an attempt to split an expensive ferrite toroid core need not end in disaster. A method that works well is to lay a straight-edge across the middle of the core, separating it into two equal parts. A pencil is used to mark the ferrite ring at the two places where the straight-edge crosses. Then use the edge of a small triangular file to saw along the pencil lines. Sawing from below the original line and at the sides of the ring helps. It's usually not necessary to saw very far before the core breaks.

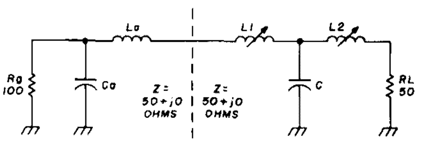

fig. 4. Inductance-tuned matching network.

The break may be slightly jagged, but not sufficiently so to make the core unusable. In stubborn cases, gripping each half of the core (protected by masking tape) in a small portable vise and striking a blow to one half, or to a chisel along the filed slot, should be considered. Yes, one toroid core does supply two tuning units.

The advantage of using ferrites can be appreciated by noting that one of my experimental units using Amidon FT 114-63 material at 10 MHz exhibited an inductance ratio of 5.9 to 1 between tuning extremes.

design considerations

The theory of matching networks is very much of. an electrical-engineering specialty. Fortunately, however, tables exist for values of circuit elements for matching a variety of sources to a fixed load of 50 ohms, there being a table for each of several choices of Q and each of four basic matching circuits, with equations given.[8,9,10]

In this design I've not attempted to provide an optimum result but rather to show that an improved design is feasible, leaving the full job as a challenge to the more capable Amateur. It's relatively easy to design a circuit with tuned-inductance series arms and fixed-parallel capacitors for a 50-ohm resistive match with a chosen Q. If the inductive arms have a large tuning ratio, one can design for the 50-ohm match values toward the middle of the tuning range and accept the range of load matching made possible by adjustment of the inductance values. For my portable operations this was not an unsatisfactory procedure, since I was using resonant, but sometimes loaded, monopoles and doublets. In the worst cases, the monopole ground plane might consist of only one wire laid along the railing of a motel balcony, or a doublet might be suspended very low above ground. I generally don't try to load up arbitrary lengths of wire. I especially avoid resonant wires with feed points close to a voltage maximum.

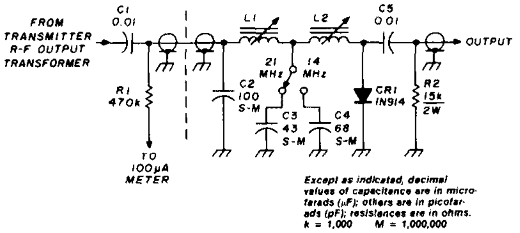

fig. 5. Circuit of experimental unit.

experimental circuit

The network I finally came up with was more of a mongrel than I had originally intended. It started out as the T network of **fig. 2** with a Q of 4 and switchable shunt capacitors for changing from 14 to 21 MHz, matching an assumed 100-ohm resistive output to a 50-ohm resistive load. I found the information shown in **table 1** by using reference 8 and making approximations. However, I wasn't able to use the original T network because, apparently, the inductance of rf chokes in the transmitter final amplifier caused a parasitic oscillation at about 4 MHz. This oscillation was eliminated by placing a 100-pF capacitor across the transmitter output.

table 1. Computed values for proposed T network of fig. 1; initial data used from reference 8 ($Q = 4$, $RG = 100$ *ohms*, $RL = 50$ *ohms*).

f (MHz)	X_{L1} (ohms)	L1 (μH)	X_{L2} (ohms)	L2 (μH)	X_C (ohms)	C (pF)
14	400	4.6	287	3.3	174	66
21	400	3.0	287	2.2	174	44

The new circuit could be split and described as a number of different combinations. After examining published tables in reference 10, I chose to look at it as an approximation of **fig.** 4, an L network of $Q = 2$, transforming 100 ohms to a 50-ohm resistive load — the load being a symmetrical lowpass T network of $Q = 6$ with 50 ohms resistive output and input. **Table 2** gives circuit parameters for 14 and 21 MHz.

Fig. 5 shows practical adaptation of **fig. 4**. The unit was connected to the output of a simple rf ferrite toroid transformer in the output circuit of a 2-3 watt transmitter for 14 and 21 MHz. For capacitor C2 I compromised on a single 100-pF silvered-mica unit. For tuning I used a 100-microampere meter in the transmitter to measure relative output. The 1N914 diode, CR1, provides a measure of peak rf output across itself. It charges C1 and C5. The discharge of C1 through R1 (470k) provides the current to give a relative reading on the meter. Resistor R2 is used as a means of draining atmospheric electrical charges off the antenna.

table 2. Computed values for circuit of fig. 4, approximated in final unit (data from reference 10). Rg is 100 ohms resistive; RL is 50 ohms resistive.

f (MHz)	X_{Ca} (ohms)	Ca (pF)	X_{La} (ohms)	L_a (μH)	X_{L1} (ohms)	L1 (μH)	X_{L2} (ohms)	L_2 (μH)	X_C (ohms)	C (pF)
	100		50		300		300		154	
14		110		0.58		3.4		3.4		74
21		70		0.39		2.3		2.3		49

tuning considerations

When one tunes for a maximum relative output voltage at CR1, this is essentially a measure of the voltage across the antenna cable and therefore a measure of the maximum output of the transmitter for a particular feed line and antenna, irrespective of SWR. One must assume, of course, that as a result of previous experience with the antenna, the SWRs are not unreasonable if amplitude readings and dial settings are similar to those that have been noted under controlled conditions with an SWR meter in the line. Self-oscillation of the final (not keyed in my transmitter) can usually be recognized as small key-up readings or readings without rf drive. VHF parasitics sometimes appear as very large meter readings. In one case when the antenna cable's shield was mostly torn from the plug, so that the final amplifier saw a load favorable for VHF oscillation, there was a very large apparent output reading at unusual tuning positions, but only during key down. An SWR meter showed very high readings.

construction

In the physical design of the unit, it was possible to build inductors with such a wide tuning range that no bandswitching of inductance was needed. In fact, L_a as seen from **table 2** was so much smaller than L1 that I simply regarded it as a part of L1, which I then wound identical to L2.

I designed the matching unit to fit into a Bud aluminum minibox (natural finish) CU3017A or equivalent, 3-1/4 by 2-1/8 by 1-1/8 inches (83 by 54 by 29 mm). **Fig. 6** shows the layout in the cover of the box. I mounted each inductor on an acrylic plate about 1-1/2 inches (38 mm) square. The central bushing is nylon 13/32 inch (10 mm) in diameter and 17/64 inch (6.7 mm) high, drilled for a standard 1/4 inch (6.4 mm) shaft of Formica. Using the techniques of reference 3, I cemented the bushings to the plates, which had oversized shaft holes.

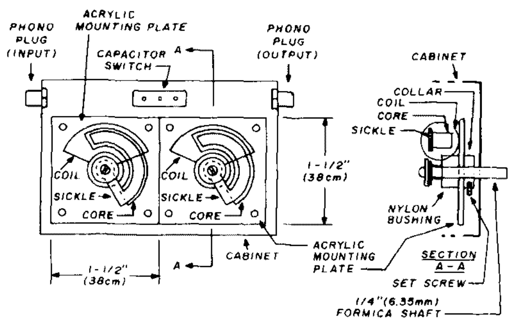

fig. 6. Matching network assembly.

For each half-toroid I wound twenty-two turns of No. 20 (0.8 mm) enameled wire on a 3/8 inch (9.5 mm) dowel, two more turns than would be used, because the coil would unspring slightly. A little more coil width would have allowed more core clearance in the finished product. I carefully wrapped this coil around the bushing, cementing twenty turns to the bushing and plate with Duro cement, having first brought leads out through holes in the plate. An rf-coil cement, Duco, or epoxy would all have done equally well. Holding the coil with a rubber band or small clamp until the cement hardens may be helpful.

For the cores, I split an Amidon 114-63 core as described above and in reference 3. It was necessary to use washers between the sickle hub and shaft end to space the core properly inside the coil with the shaft all the way into the nylon bearing. To hold each assembly in place I made shaft collars with set screws.

unwanted-output suppression characteristics

Fig. 7 shows the test setup for measuring unwanted-output levels relative to the level of the desired output. The low-power transmitter-matching circuit under test feeds a 50-ohm load of 8-watt dissipation, consisting of four 200-ohm, 2-watt resistors in parallel. This load is bridged by an arbitrary bleeder consisting of a 1000-ohm half-watt resistor in series with a 50-ohm half-watt resistor feeding a short piece of 50-ohm cable.* This cable can plug into one terminal of a precision variable rf attenuator; the one in this case was a unit once made by Hewlett Packard. I also used a high-frequency signal generator set arbitrarily at a high 50-ohm output level (mine was an old unit by Clemens Manufacturing Co.). Its output through 50-ohm cable can also plug alternatively into the attenuator terminal.

*For greater precision the capacitances across the resistors should be accounted for, as in the case of the attenuator in an oscilloscope rf probe.

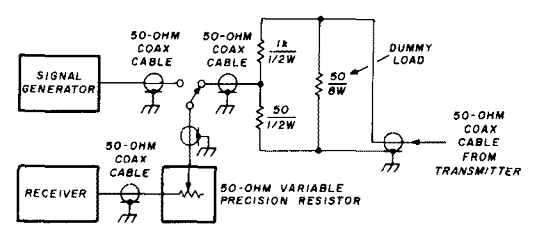

fig. 7. Layout for measuring relative strength of unwanted output components.

The other terminal of the attenuator goes to a stable communications receiver with a good AGC meter (S-meter). Mathematically it can be demonstrated that when the cables are matched at the sending end (not necessarily at the receiver) on any one receiver frequency setting, the output from the bleeder fed through the attenuator, and that from the signal generator fed through the attenuator, are the same — except for attenuator settings when the AGC meter reads the same. Negligible cable losses are assumed.

The procedure for measuring relative unwanted output is as follows:

1. The bleeder output from the transmitter dummy load is put through the calibrated attenuator and a setting, A, made to give a convenient AGC-meter reading with the receiver resonated to the transmitter fundamental frequency. Setting A is noted.

2. The signal generator is now plugged into the attenuator instead, with at least 20 dB of its own 50-ohm attenuator in use (to make sure of having a 50-ohm source). It is tuned to the receiver and a new attenuator setting, B, is made to bring the AGC-meter needle to the same point as before. The setting is recorded. The receiver now shows that the signal generator output and the bleeder output are equal.

3. With the transmitter running again, a harmonic or other unwanted frequency is tuned in.

4. Again the transmitter bleeder output through the attenuator is adjusted on the attenuator dial to a new convenient AGC-meter reading. The new attenuator setting, A', and the new meter reading are recorded.

5. Again a new signal-generator output (with its own attenuator unchanged from **step 2**) on the new frequency is put through the attenuator. The procedure of **step 2** is followed, and attenuator setting B' for the AGC-meter reading of **step 4** is recorded.

6. The number of dB that the signal generator was below the transmitter-bleeder output for the fundamental is $(A\text{-}B)$. The number of dB for the unwanted signal is $(A'\text{-}B')$, which may be negative, so the unwanted signal is $(A\text{-}B)\text{-}(A'\text{-}B')$ below the fundamental in decibels.

Table 3 shows the approximate results of the tests at 14 MHz.

some final observations

I've demonstrated that it's possible to build a simple tuned output network for a low-power rf final amplifier that has matched portable antennas in a variety of situations and is, at the same time, a lowpass filter with very satisfactory suppression of unwanted frequencies. However, as stated at the start, this achievement raises more questions that it answers.

In the first place the design, as mentioned above, was not optimized and I have not determined the exact range of loads that can be matched. Also, for the range of different possible settings, there must be a wide range of Qs, that I've not calculated. This is fair-to-poor ham practice, but terrible engineering. There's been a lot of theoretical research on matching networks and some practical engineering data published, but it appears that much more application information is needed.

The tables of matching-network parameters mentioned earlier are an example of good application information, but they are chiefly concerned with matching a fixed load, generally 50 ohms resistive. The mere question of how to express load-matching capabilities and limitations of a tunable multi-element circuit is a difficult one to answer. Standing-wave ratio is a convenient measure of a mismatch to be matched, yet anyone familiar with the Smith chart knows that any SWR circle intercepts a variety of circuit parameters and that it is these values that limit matching capabilities, not the SWRs.

Returning to **fig. 2**, for a given design one could superimpose parametric curves on a Smith chart — for instance, varying L1 with L2 and C being fixed. One could do this for different values of L2 and C. From these curves one could see limits of SWR and circuit parameters for a particular design. However, the real problem is to *optimize* a design, starting with expressed limits of loads to be matched. We have here a problem worthy at least of a Master's degree

table 3. Approximate attenuation of unwanted signals from low-power transmitter at 14 MHz fed through antenna-matching unit to 50-ohm resistive load. Transmitter final was push-pull 2N3948s.

f (MHz)	dB below wanted signal
28	55
42	70
7 (fromVFO)	48

for some technically oriented engineering-school ham with skill in computer programming.

Then there's circuit Q, which will vary as the circuit is tuned. Does present textbook material do enough to relate the defined Q of a filter-circuit element to its overall Q, and how does this relate to the simple $\omega L/R$ of an LRC tank circuit so well explained in the textbooks? Then, what about the low Qs (some say not above 4) so frequently specified? The limitation here cannot be the passband as it is with vacuum-tube power-output circuits. I must guess that the higher-Q transistor-output circuits might tend to oscillate at some unwanted frequency where the matching circuit no longer matches but presents the collector circuit of the final amplifier with a load that would be favorable for oscillation — but I've not seen this in print. Passband characteristics involving harmonic suppression have been treated in various places. They must be of concern in an optimum design.

Finally there is the question of the behavior of the core. Ferrites saturate at a low magnetomotive force, but with a half-toroid we have a big air gap. Nevertheless, we should design for a large enough cross-section area to stay far below saturation. In fact, core nonlinearity produces harmonics that did not exist in the transistor output. To know where we stand relative to saturation requires knowledge of the rf current and the core position for each set of load parameters. High currents cause excessive heat, which will do permanent damage to a core.

Perhaps we should raise that proposed Master's degree to a Doctorate. I'm sure JA6GW already qualifies,[4] but unfortunately he's shown us only part of his technique. It's quite likely, though, that experimentation alone will produce some useful, but not necessarily optimum, designs for higher-powered equipment than I've been using. Go to it, experimenters.

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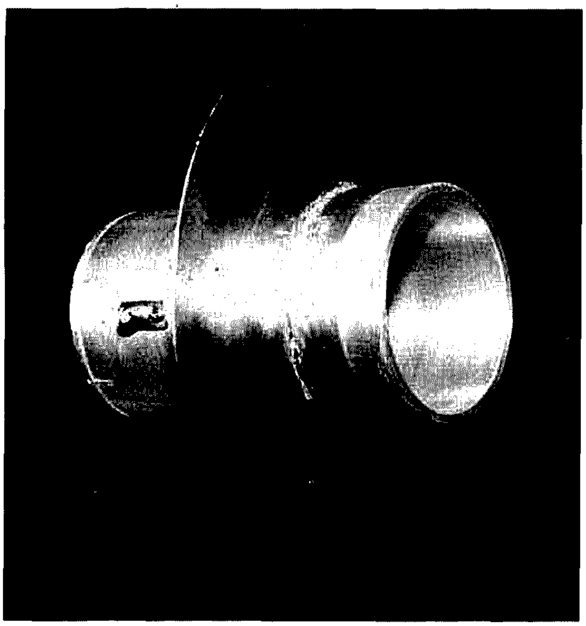

second-generation cylindrical feedhorns

Improved feedhorn provides superior parabolic antenna system performance

My original article describing cylindrical feedhorns[1] for use with parbolic reflectors appeared in *ham radio* in May, 1976. Judging from the number of inquiries that have been — and are still being — received, the subject is obviously pertinent to many Amateurs and experimenters interested in working in the UHF and SHF ranges. Variations of the design have been used on the 1296- and 2304-MHz Amateur bands as well as the MDS[2] and ITFS[3] bands. The design is also well suited for use in the 3300-3500 MHz Amateur band.

I recently experimented with cylindrical feedhorns for reception of satellite TV signals in the 3.7-4.2 GHz band. The design requirements here are similar, but in my case much more stringent — not because the frequency is higher, but because I chose to use a very small-diameter dish reflector (8-foot, or 2.4 meters). Those who are familiar with TVRO design requirements know that 10-foot (3-meter) or larger reflectors are almost always specified. Therefore, everything in my system had to be exactly right to produce acceptable satellite TV pictures using the 8-foot (2.4-meter) dish. This meant that I had to pay particular attention to details.

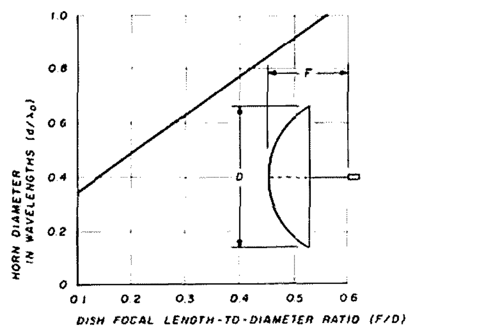

fig. 1. Feedhorn diameter in wavelengths as a function of focal length/diameter ratio, F/D, of the parabolic reflector.

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While this activity is not normally considered Amateur Radio in the usual sense, the modifications I had to make to the original design are certainly applicable to the UHF and microwave Amateur bands. The purpose of this article is to describe the changes and the associated improvements in performance that were achieved. This information should be helpful to Amateur experimenters and others working with parabolic reflectors who are interested in obtaining superior performance from their antenna systems.

a review of feedhorn parameters

Important feedhorn parameters are length, diameter, and probe location. The most important of these is the inside diameter of the horn, which is tailored to match the associated reflector. The probe location is calculated after the diameter is established.

The original article specifies a minimum diameter of about 5.68 inches (14.4 cm) for the 1215-1300 MHz application to operate above the cutoff frequency of the circular guide. A horn this small has a very broad beam and so would normally be used with a very deep dish. Large-diameter horns produce narrow patterns and higher gains. Generally the diameter is selected to match the F/D ratio of the associated parabolic reflector to achieve optimum design. A match is achieved when the gain of the horn off boresight at the periphery of the dish is approximately 10 to 15 dB below the gain on boresight. This point is illustrated in fig. 3 of the original article. Note that my 3.7-4.2 GHz horn has a diameter of 2.25 inches (5.7 cm), which provides a good match to my 0.387 F/D ratio 8-foot (2.4-meter) reflector.

Fig. 5 of the original article was difficult to read because the graph contained no grid. This important graph has therefore been reproduced here in **fig. 1**, but in a more universal form. Instead of specifying diameters for a specific frequency, diameter is specified in terms of wavelength, d/λ_0. This makes the graph useful at any frequency. For example, from **fig. 1** the diameter of a horn used with a dish having an F/D ratio of 0.387 is $0.75\lambda_0$. Therefore, the 1296-MHz feedhorn should have a diameter of 6.83 inches (17 cm):

$$d = 0.75\lambda_0$$
$$\lambda_0 = 9.113 \text{ inches (23 cm)}$$
$$\text{Therefore, } d = 0.75 \times 9.113 = 6.83 \text{ inches (17 cm)}$$

The relatively critical probe location can be determined once the horn diameter is established. The original article describes the probe as being located a quarter *guide* wavelength from the shorted end of the horn. The probe length is slightly shorter than a quarter *free-space* wavelength because of end capacitance. Reference should be made to the original article, which fully describes probe parameters and the tune-up procedure.

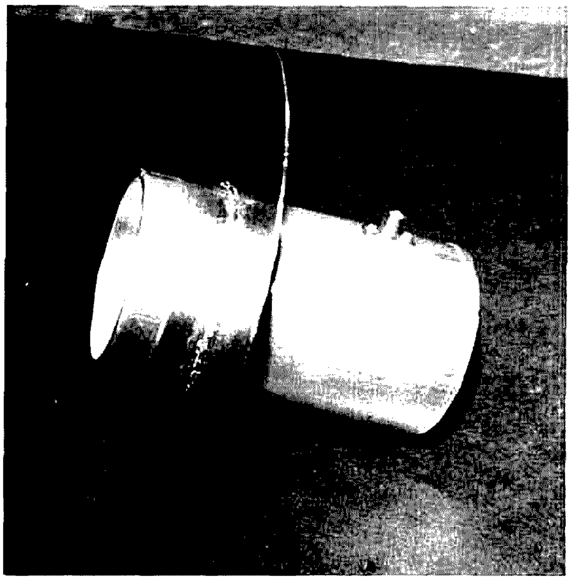
problem areas

Up to this point it has been assumed that the beam cross-section is circular and therefore that the reflector would be equally illuminated all around its circumference. Fortunately this is as very good assumption for cylindrical horns, especially those having large d/λ_0 ratios. In contrast, rectangular waveguide horns, which do not produce circular beams, require that a flare be added in the electric plane to achieve uniform illumination* in both the electric and magnetic planes.

Large-diameter cylindrical horns, such as might be used with shallow reflectors, generally exhibit side lobes as high as 8 to 10 dB below the peak of the main beam. This is not efficient and is particularly undesirable in TVRO systems.

Besides beam cross-section ellipticity and side lobes, there is a third effect relating to the abrupt discontinuity where the wave is launched from the open

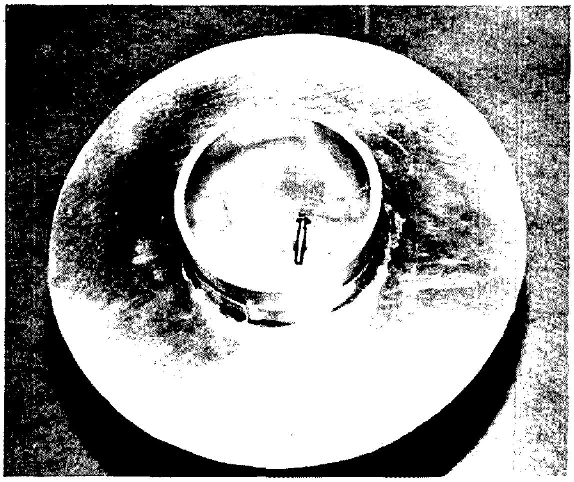
*The reference here to illumination of the dish denotes use as a transmitting system. Based on the reciprocity theorem, the system will work equally well for receiving purposes, but it is probably easier to visualize in the transmitting mode.



Second-generation feedhorn has space-age look. This 2¼-inch (15.7-cm) OD horn operates across the 3.7-4.2-GHz satellite TV band. Rf-choke disc increases gain by 2 dB and significantly improves overall system performance.

end of the horn. The discontinuity causes what is sometimes referred to as a back radiation.[4] The amount of back radiation is large for small-diameter horns but approaches zero for diameters larger than one wavelength. In the present application, horn diameters greater than a wavelength would be used with only very shallow (large F/D) dishes.

The cylindrical feedhorn is in reality a short section of circular waveguide with its open end coupled into space. Since the impedance of circular guides is always greater than the 377 ohms of free space,[5] a small amount of energy will be available for back



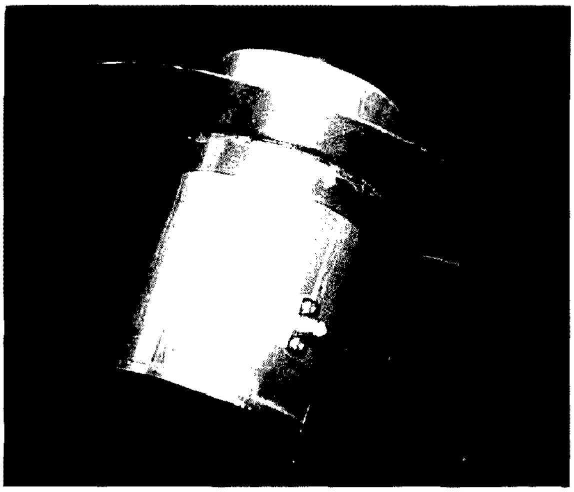
Another view of the horn showing probe location, which is calculated after horn diameter is established. The most critical horn parameter is inside diameter, which is designed to match the associated reflector.

radiation, while some energy may be reflected back into the coaxial input circuit. A means therefore is needed to reduce the discontinuity at the mouth of the horn; this should reduce VSWR and increase gain and efficiency.

matching the feed horn to free space

Experiments have shown that the addition of an rf choke on the outside of the feedhorn near the opening is very effective in reducing back radiation and providing a better impedance match. Measurements show that the resulting increase in gain of the main lobe is between 1 and 3 dB, depending on the ratio of d/λ_0. VSWR measurements show that best impedance match is obtained when the choke is located at the best gain position.

The choke is a flat washer positioned coaxially on the horn and located behind the open end. The choke used for the 4-GHz horn was 6 inches (15.25



The flat disc rf choke is very effective in reducing back radiation and providing a better impedance match. VSWR measurements show that the best impedance match occurs when the choke is located at the best gain position. Details for adjusting the choke are given in the text.

cm) in diameter and it was positioned approximately 1-1/4 inches (3.175 cm) behind the opening. Note that the distance from the open end of the horn along the metal surface to the periphery of the choke is approximately one wavelength. Since this distance is critical, provisions are made for adjusting the position of the choke for tuning purposes. The effectiveness of the choke becomes clearly evident as it is moved back and forth during gain tests. Also, pattern tests show that the choke is effective in reducing minor lobes to very low levels and circularizing the

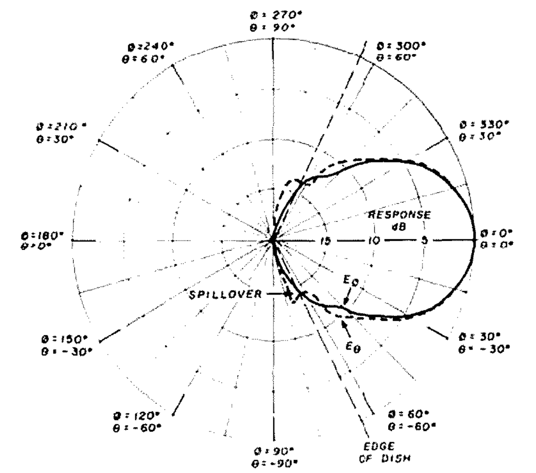


fig. 2. Patterns of the 4-GHz feedhorn after having been adjusted for maximum gain.

beam cross section. Thus, the choke is instrumental in improving *all* of the potential problem areas. **Fig. 2** shows the patterns of the 4-GHz horn in both the electric and magnetic planes after the choke had been adjusted for maximum gain.

Fig. 3 illustrates the mechanical details of the 3.7-4.2 GHz horn, including the choke. Note that all of these dimensions can be scaled to other frequencies in proportion to wavelength except for probe location. The latter is a function of guide diameter, which in turn depends on F/D ratio of the reflector. **Fig. 4** is a graph showing the probe location in terms of d/λ_0.

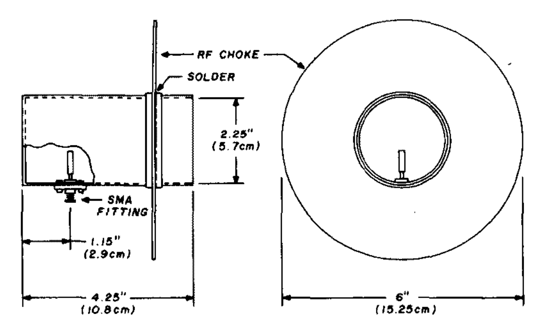


fig. 3. Mechanical details of improved 3.7-4.2 GHz feedhorn.

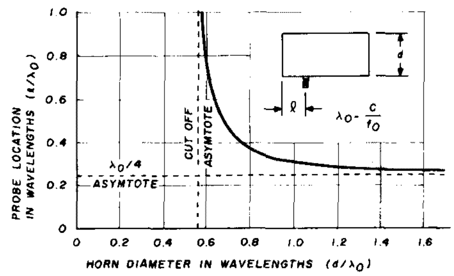


fig. 4. Probe location in terms of horn diameter in wavelengths.

design example

The amount of Amateur activity on 1296 MHz has been increasing rapidly during the past few years. Seven-foot (2-meter) diameter dishes are quite popular on this band because commercial units intended for UHF TV are easily modified for use at 1296 by the addition of screening and a more suitable feedhorn. It is appropriate, therefore, to include with this article a 1296-MHz design example of an improved feedhorn for this application.

Most 7-foot (2-meter) reflectors have an F/D ratio of approximately 0.38. From fig. 5 of the original article, the horn diameter is 6.75 inches (17 cm). The length is 12-14 inches (30-36 cm), but this dimension is not critical. Free-space wavelength is calculated as follows:

$$\lambda_0 = c/f_0$$

$$\lambda_0 = \frac{3 \times 10^{10}}{1.296 \times 10^9 \times 2.54} = 9.11 \text{ inches } (23 \text{ cm})$$

where λ_0 = *free-space wavelength (inches)*

$c = 3 \times 10^{10}$ *(cm/sec)*

$f_0 = 1.296 \times 10^9$ *(Hz)*

Guide cutoff wavelength is calculated as follows:

$$\lambda_c = 3.42r$$

where λ_c = *cutoff wavelength*

r = *horn radius*

$$\lambda_c = 3.42 \frac{6.8}{2} = 11.63 \text{ inches } (29.5 \text{ cm})$$

The cutoff frequency, f_c, is 1016 MHz.

Finally, guide wavelength, λ_g, is:

$$\lambda_g = \frac{9.11}{\sqrt{1 - \left[\frac{9.11}{11.97}\right]^2}}$$

$$= 14.057 \text{ inches } (35.7 \text{ cm})$$

In other words, the probe should be 3.5 inches (8.9 cm) from the shorted end of the horn. The probe is slightly shorter than $\lambda_0/4$, or about 2-17/64 inches (5.75 cm). Its length should be adjustable over a distance of about ± 1/4 inch (6mm). The adjustment for minimum VSWR should be made with the choke located at the maximum gain position. The technique illustrated in fig. 6 of the original article can be used for probe adjustment.

The 1296-MHz feedhorn should be equipped with an 18.5-inch (47-cm) diameter, 0.032-inch (0.8-mm) thick brass rf choke, located approximately 2-1/2 inches (6.35 cm) behind the open end of the horn. The inside diameter of the choke should be greater than the outside diameter of the horn, so that a 1-inch-wide, 0.032-inch-thick strip of brass can be soldered to the inside of the choke. This strip acts as a guide for adjusting the position of the choke, as illustrated in **fig. 3**. It also provides good electrical contact with the outer surface of the horn. Be sure the sliding surface is clean and free of paint and other insulating materials. Once the choke has been positioned for maximum gain, the outside surface of the horn and the choke can be sprayed with paint to protect these surfaces from the weather.

A typical 2304-MHz design uses a 4-inch (10-cm) diameter coffee can 5½ inches (14 cm) long with a 10-1/2 inch (26.7-cm) diameter choke. The choke is

1-1/4 inches (3 cm) from the open end of the horn. The probe (monopole) is located 2-3/8 inches (6 cm) from the shorted end of the horn. The improvement in gain due to the choke for this horn was 2.0 dB. VSWR was measured at less than 1.1 between 2.0 and 2.5 GHz.

The choke can also be made from 0.032-inch (0.8-mm) aluminum sheet stock. Cut the inside diameter 1-1/2 inches (4 cm) smaller than the OD of the horn. Serrate the hole with a saber saw or hacksaw blade to the horn diameter, then bend the tabs at right angles to match the contour of the horn. Cuts should be made every 20 degrees or so. Finally place a hose clamp over the tabs to provide both a good electrical and mechanical contact with the horn.*

adjusting the choke

A suggested test setup for adjusting the position of the rf choke for maximum feedhorn gain is shown in **fig.** 5. A signal generator or other rf power source drives a dipole illuminating antenna. The dipole should have a reflector as shown, and a balun might also be used to connect the unbalanced generator to the balanced dipole antenna terminals.

The horn antenna under test should be located at a distance from, and looking directly at, the illuminating antenna. A separation distance of 8 or 10 feet (2 or 3 meters) is generally satisfactory, although closer spacing may be necessary at higher frequencies. Orient the antennas so their polarizations match. Connect the output of the feedhorn to the input of a sensitive rf detector driving a microammeter or dc VTVM. If an rf amplifier is available, it can be inserted between the horn and rf detector to obtain greater measurement sensitivity. Another option is to connect the output of the feedhorn to the input of a converter and receiver combination; the receiver's S-meter can serve as the detector. In none of these situations is the radiation pattern of the transmitting antenna particularly critical, except that reasonable directivity is necessary to avoid reflections from nearby objects if the test is run indoors.

After having obtained a preliminary detector reading, slide the choke back and forth to identify the point that provides maximum detector current. Gain should be approximately 1.5 to 2.5 dB greater with the choke than without it. You can check this by removing the choke and noting the increase in generator output power necessary to recover the lost gain.

*Templates for several horn sizes are available from the author. Please state horn diameter and enclose $2.00 to cover the cost of printing and mailing.

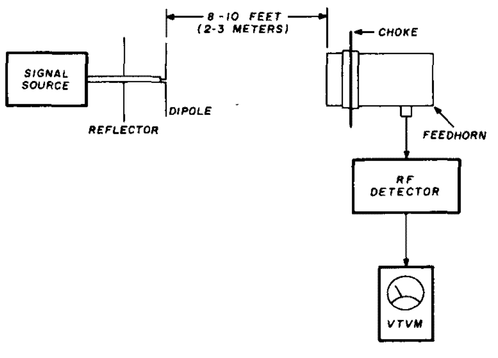


fig. 5. Test setup for choke and probe adjustment.

closing remarks

We Amateurs have known as far back as we can remember that the most simple and least expensive way to improve system performance is by increasing antenna gain. Because this is equally true for receiving and transmitting, any successful effort to improve the antenna is felt at both ends of the contact.

As we move from VHF to UHF in our quest for new experiences, we find that the parabolic antenna system is used more and more. While there are very few dishes in use at 432 MHz and below — other than at a few EME installations — fifty-three percent of all stations listed in the 1981 1296-MHz directory[7] who specified their antenna type are using parabolic reflectors. These range in size from 30 inches (0.75 meter) to 25 feet (7.6 meters) in diameter. The move to 2304 MHz will very likely see even greater use of the dish.

In my case, the need to stretch antenna performance to the limit in an effort to achieve "sparklie-free" TV images with the use of a very small parabolic reflector provided the impetus for improvement. It seems to me that Amateur EME and long-haul over the horizon (forward scatter) circuits stand to benefit also. I shall be delighted to hear from Amateurs and experimenters who prove this to be a correct hypothesis.

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ham radio

A grounded, vertically polarized antenna with some interesting features

the half-delta loop

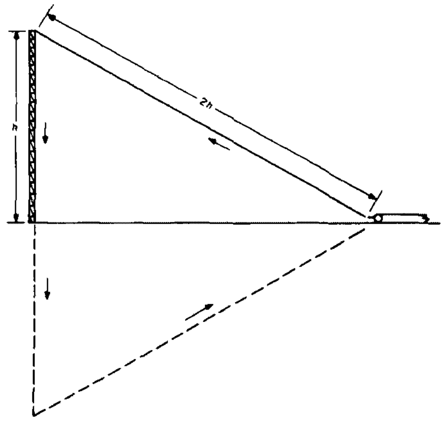

fig. 1. Grounded half-delta loop antenna and its image in the ground plane.

In a recent article on the half-sloper antenna,[1] I suggested that a half-delta loop configuration would make a better antenna system. That is, the sloping wire would be attached to the top of a grounded tower, and this wire would be end fed, against ground at its far end (see **fig. 1**). The length of the half-delta loop, including tower height plus length of the sloping wire would be an electrical half wavelength, but the loop is "full-wave resonant," if account is taken of its image in the ground plane. Obviously, characteristic of monopole grounded anten-

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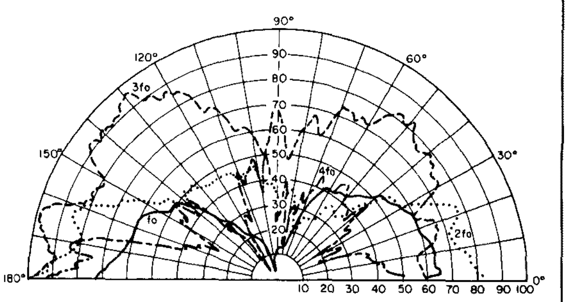

fig. 2. Vertical radiation pattern, vertical polarization, measured in the plane containing the half-delta loop, for the lowest resonant frequency (f_0) and for various harmonic frequencies ($2f_0$, $3f_0$, and $4f_0$).

nas, the half-delta loop will work best if a ground screen is used to improve the image that it sees of itself in the ground plane, and to provide a low resistance for return current flow in the ground to the grounded side of the coaxial feed. At the very least, a wire buried in the ground should connect the base of the tower to the shield of the coaxial feed cable, and two six-foot (2-meter) ground rods should ground the tower and the ground side of the feed.

design considerations

While other configurations will work, the antenna discussed here was arranged as a delta loop; that is, the antenna and its image have the shape of an equilateral triangle. Thus if the tower height is h, the length of wire should be $2h$, and therefore:

$$3h = k\lambda/2$$

$$h = \frac{k\lambda}{6}$$

where k is a factor greater than 1 that relates the physical and electrical lengths of the antenna. For the model antenna built for test and evaluation at a scale frequency of 200 MHz, k was experimentally determined to be about 1.12.

Thus the table below gives approximate dimensions for half-delta loop antennas for 160, 80, and 40 meters.

f (MHz)	tower height, h, feet	(meters)	length of sloping wire, feet	(meters)	band (meters)
1.8	100	(30.5)	206	(62.8)	160/80/40
3.6	50	(15.3)	103	(31.4)	80/40/30/20
7.15	25	(7.6)	52	(15.8)	40/20/15/10

Unlike dipoles, which are resonant at f_0, $3f_0$, $5f_0$, etc., the half-delta loop is resonant at all harmonics of its fundamental frequency f_0, $2f_0$, $3f_0$, $4f_0$, etc.

Measured radiation patterns for the modeled antenna, measured on the National Research Council, Ottawa, antenna pattern range,[1] are given in **figs. 2** and **3**. The curves in **fig. 2** show the vertical radiation pattern for vertical polarization, measured in the plane containing the antenna, at the lowest resonant frequency of the antenna, f_0, and for various harmonics of this frequency ($2f_0$, $3f_0$, and $4f_0$). While the polar pattern becomes more complicated at the higher harmonics, the antenna radiates essentially like a monopole antenna in that the polarization is vertical, and maximum gain is directed toward the horizon.

The curves in **fig. 3** show the azimuthal radiation patterns for vertical polarization for a launch angle of 10 degrees above the horizon, measured at these same frequencies. The polar pattern at the fundamental frequency is interesting; the antenna radiates in the plane broadside to it like two quarter-wave monopoles in phase. In this figure, the tower was located at the center of the polar diagram, and the delta loop had its apex directed toward the 0 coordinate. At harmonic frequencies the antenna exhibits a different directivity. The maximum gain occurs in the plane containing the antenna, rather than broadside to this plane, with the greatest gain in the direction away from the tower and its feed; and nulls appear in the plane broadside to the antenna — the nulls at $3f_0$ are particularly deep.

The vertical radiation patterns for horizontal polarization in the plane broadside to the half-delta loop

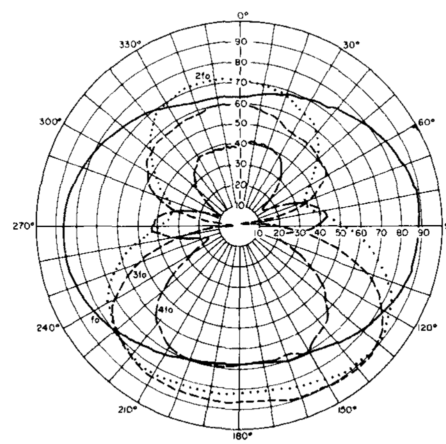

fig. 3. Azimuthal radiation pattern, vertical polarization, measured at an angle above the horizon of 10 degrees for the half-delta loop at its lowest resonant frequency (f_0) and for various harmonic frequencies ($2f_0$, $3f_0$, and $4f_0$). The delta loop was located at the center of the polar plot with its apex directed toward the 0-degree coordinate.

were also measured, and although these patterns are not shown, the horizontal field was small (especially at f_0 and $2f_0$). That is, the antenna radiates dominantly like a vertically polarized antenna.

The input impedance of the antenna, mounted on an aluminum sheet, was about 74 ohms at f_0, and the SWR was less than 2:1 at the second and third current mode resonances, which occurred at frequencies of 1.7 and 2.71 f_0 (that is, about 10 percent lower than exact multiples of the fundamental frequency).

influence of ground conductivity on the vertical pattern

While we have not calculated the pattern for antennas mounted on a finitely conducting earth, the effect is expected to be like that for a vertical monopole antenna. **Fig.** 4 shows, for reference, calculated patterns for a quarter wave monopole antenna above earth having poor and good conductivity, compared with sea water, for 4 and 14 MHz.[2] The gain (greater than 2.15 dBi) comes about by the fact that a grounded monopole radiates into a hemispherical space, whereas a dipole antenna in free space radiates in all directions (over spherical space).

In concluding this brief discussion on the effect of the finite conductivity of the ground on the vertical radiation pattern of a vertically polarized antenna, and on the need to provide a ground screen beneath a current-fed grounded antenna, let me comment on a moot point not well understood. A radial ground screen beneath the antenna provides a low resistance path for the return current flow to the base of the antenna, or to the ground side of the coaxial feed in the case of the half-delta loop antenna. This is necessary to reduce the effective ground loss resistance, so that the antenna current contributes to radiation and not to ground loss. The ratio of the radiation resistance to the ground loss resistance referred to the feed point must be high for good radiation efficiency. However, to launch sky waves at a low elevation angle (less than 10 degrees) above the horizon, the ground conductivity fifty or more wavelengths in front of the antenna is important. As shown in **fig. 4** the effect of the conductivity of the earth is large, particularly at low angles, and the influence of the ground extends well beyond the limits of practical ground screens. This point was discussed in my subsequent article.[3]

The various patterns shown in **figs. 2** and **3** are relative. While no attempt was made to measure the gain of the antenna at the harmonic frequencies, it should be noted that the pattern for the *fundamental frequency*, f_0, was referenced to a half-wave dipole antenna one-quarter wavelength above the ground plane; and 45 on the relative-amplitude scale corresponds to approximately zero dBd. The antenna therefore exhibits a maximum gain approximately 6 dB over a dipole in free space.

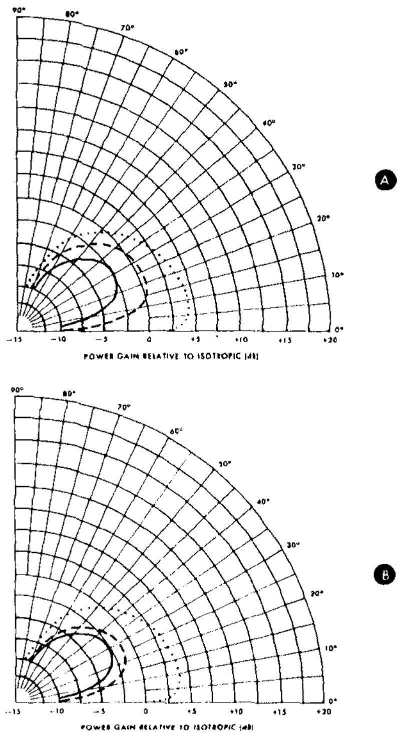

fig. 4. Theoretical vertical radiation pattern for a vertical quarter-wave antenna over three types of ground: poor (solid line), good (dashed line), and sea water (dotted line); calculated for two frequencies, 4 and 14 MHz, (A and B respectively). (Taken from reference 2.)

acknowledgements

I wish to express my thanks to L.R. Bode of the Communications Research Centre, Department of Communications, Ottawa, who built the model antenna and measured its impedance, and to W. Lavrench (VE3LAV) and J.G. Dunn, who measured the antenna pattern on the National Research Council's (Ottawa) antenna pattern range.

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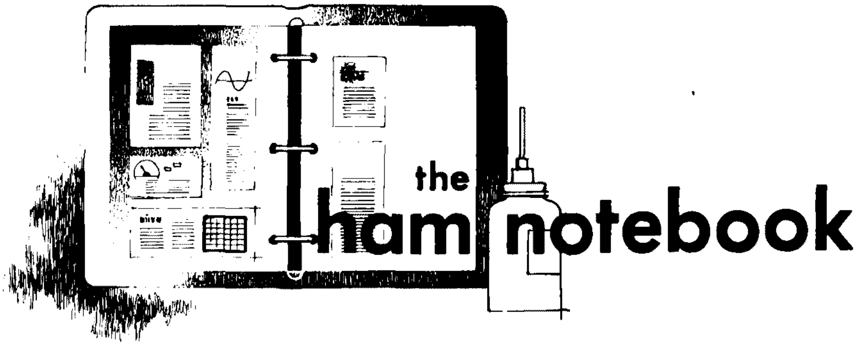
ham radio



inexpensive automatic send/receive change-over relay

Many older tube transmitters using cathode keying can be retrofitted to provide inexpensive and automatic antenna send/receive change-over. All that's necessary is an antenna change-over relay controlled by the same circuit that grounds the final-amplifier tube cathode. However, unless one provides for a delayed release, the change-over relay "clunks" along with every depression of the key.

circuit

With the addition of a diode, a resistor, a large capacitor, and a sensitive relay (**fig. 1**), the initial depression of the key enables the antenna change-over relay as before, but the relay will not return to the receive position during subsequent code spaces until a short time delay has occurred. This time delay can be controlled by the sensitivity and dropout characteristics of the relay, and by the size of the capacitor. The delay can be made long enough to bridge spaces between characters, or even between words, with the proper choice of components.

operation

Assume that the key has been open for some time. The capacitor will have been charged to some positive voltage, there will be no potential difference across the sensitive relay to cause any current flow, and both relays will be de-energized (**fig. 1**). Closing the key will discharge the capacitor through the diode and the small series resistor (the resistor is included only to protect the diode by limiting the discharge current). This action will produce a potential difference across the sensitive relay, causing current to flow through it. Its closing then will activate the antenna change-over relay. If an additional contact on the antenna change-over relay controls the B+ to the transmitter final amplifier, this entire switching process will be completed by the time any rf power has been generated, and the normal load will be presented to the final amplifier.

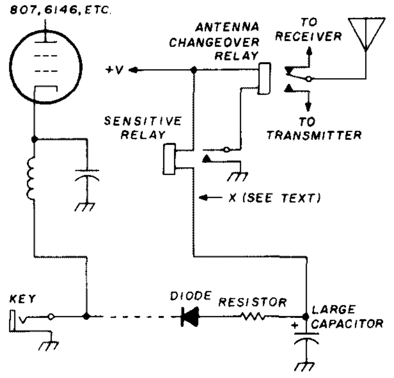


fig. 1. Inexpensive automatic send/receive change-over relay. Values for the diode, resistor and capacitor are discussed in the text.

When the key has been released, the diode will prevent leakage current through the tube from keeping the capacitor charged. (Note that the diode's PIV rating must be sufficient to withstand the key-up voltage at the cathode.) Thus, the capacitor will begin to charge from the current flowing through the sensitive relay. However, this current will keep the sensitive relay energized until the voltage across the capacitor has increased to the point that the potential difference across the sensitive relay is less than its dropout voltage (a relay's dropout voltage is always less than its pull-in voltage). If the key recloses before dropout occurs, then the capacitor will again discharge, and the cycle will repeat when the key is released. If the key remains open long enough (as at the end of the message), both relays will de-energize and reception again will occur.

additional notes

Since no internal connections to the transmitter are required, this change-over scheme can also be implemented as an outboard accessory. The relay can include contacts for more than antenna and transmitter power switching. Additional contacts can ground the receiver's antenna input, turn off the receiver's B+, turn on the linear's power, or dim the lights. In many cases the change-over relay may require a higher positive voltage than the sensitive relay (+12 volts versus +6 volts, for example); a dropping resistor may be inserted at point **X** in **fig. 1**.

final comments

The version of this circuit that I've retrofitted into two war-surplus TCS-13 transmitters used a junkbox rectifier diode, a 27-ohm, 1/2-watt resistor, a 1000-μF capacitor, and a small reed relay. The TCS-13 had *two* change-over relays. After the initial "ka-lunk," operation was blissfully quiet for about one second after the last key-down period, at which time a smaller clunk occurred, and the receiver was again operative.

Myron A. Calhoun, W0PBV

(Continued on page 42)

modifications to the Atlas 350 AGC circuit

A renewed interest in CW and comments by Doug McDougall (*ham radio*, January, 1980, page 88) led to the following modification of an Atlas 350. The AGC characteristics remained unchanged whether operating CW or SSB. On CW, a shorter delay is desired, especially when operating QSK.

The original circuit used a 1-meg resistor as the discharge path for the AGC capacitor, C313. I decided that two resistors in series, one of which could be shorted out during CW, would allow two AGC time constants. The circuit (**fig. 2**) was developed and built onto a small piece of PC material, which was soldered to the ground plane of PC320, the AGC/AUDIO board. R1 and R2 replace R316, the 1-meg AGC resistor. R1 determines the CW response, while R2 was chosen to retain the original SSB response.

The **TUNE/CW-SSB** switch provides ground and a voltage to operate the circuit. On SSB a ground is provided to Q1, which turns on, thereby turning Q2 off; R2 is now in the circuit. When in **TUNE/CW**, Q1 has a voltage applied to its *emitter and* therefore conducts less, allowing Q2 to turn on, placing its now small collector-emitter resistance in parallel with R2, which makes R1 the primary discharge resistance.

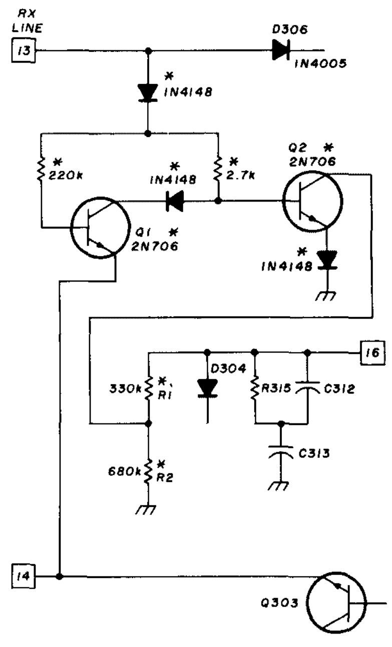


fig. 2. Modifications to the Atlas 350 AGC circuit for a shorter delay when in CW mode. Parts marked with an asterisk are added.

Performance is good, and I've noticed no degradation of operation.

Ron Lile, KØRL

tailoring audio response

This is an old idea with merit, but I've not seen it in print for some time. Listening to the receiver hiss during long periods of reception can be tiring. The audio response of a low-impedance speaker or phones may be tailored by adding an electrolytic capacitor of about 50 μF across the receiver speaker terminals or audio output jack. This cap will limit the audio high-frequency response and thus the hiss, making both CW and SSB reception more pleasant. Some overall attenuation will occur but it is relatively minor and can be compensated for by increasing the audio gain.

Paul K. Pagel, N1FB

antiflex coaxial cable connection

High onshore winds at my shack caused failure of my coax cable, the result of flexing where it emerged from the lower end of my antenna balun. I solved the problem by distributing the torque over a length of cable as shown in **fig. 3**. I used a length of fiberglass rod tip salvaged from a discarded fishing pole, which I attached to the balun with a 1.75-inch (4.4-cm) stainless-steel hose clamp. The cable was then taped to the rod as shown in the sketch. The tape was further secured by wrapping small-diameter nylon (not monofilament) line over the tape using a clove hitch. The line prevents the tape from loosening when the adhesive dries out. Finally, I covered the tape and twine with a generous coat of coil dope.

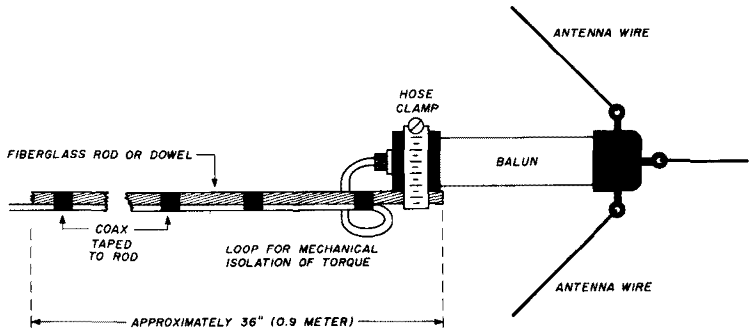


fig. 3. Method of securing coax cable to avoid failure from flexing.

While flexibility of the rod is important, a 1/4-inch (6-mm) length of maple dowel should do the job nicely if it's tapered down to about 3/16 inch (4.8 mm) at the lower end.

Lefferts A. McClelland, W4KV

a Fresnel-zone plate
for 10.4 GHz

An alternative to
a parabolic reflector for
your Gunnplexer transceiver

An increasing number of Radio Amateurs are stepping up to the 10.4-GHz Amateur band (10.0-10.5 GHz) to experiment with centimeter wavelengths and Gunn diode oscillators. The popular Gunnplexer transceivers offer the Amateur an excellent introduction to the 10.4-GHz band with a minimum of effort. (A recommended text is *The Gunnplexer Cookbook*, by Bob Richardson, W4UCH. It's available from Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $9.95 plus $1.00 shipping.)

The Gunnplexer uses a Gunn diode and a low-noise Schottky diode in a cavity that operates in the homodyne mode. The Gunn diode oscillates at the desired microwave frequency, which is the transmitted carrier frequency. The received carrier frequency is at some offset frequency (could also be the transmitted frequency that is returning to the Gunnplexer with some Doppler shift), which is mixed in a Shottky diode with the transmitted carrier frequency. The resulting i-f is then fed to a conventional high-frequency or VHF receiver for demodulation.

The common method of improving the performance of the Gunnplexer is the addition of a horn or

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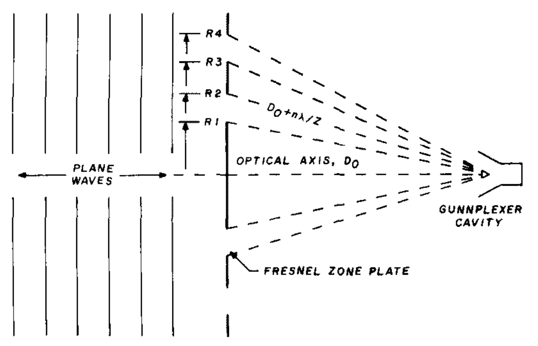

fig. 1. Geometry of the Fresnel-zone plate showing the relationship between the cut-out zones, which pass rf energy, and the center, or optical axis.

parabolic reflecting antenna to get some antenna gain. Some of the disadvantages of parabolic reflectors are that they are expensive, difficult to construct to the required tolerances, and difficult to mount or move because of their weight. This article describes an alternative antenna that yields results comparable to a parabola, yet is inexpensive and lightweight. Such an antenna is a Fresnel-zone plate.

description

The Fresnel-zone plate consists of a flat sheet of material that is opaque to 10.4-GHz energy (aluminum or copper foil) with concentric circular zones cut out to pass rf. The zones are spaced such that each zone is one-half wavelength greater in path length from the plate to the Gunnplexer cavity, out from the center zone, which is a straight-line path (**fig. 1**). The result is that each zone passes rf spaced one wavelength and adds constructively to the intensity of the rf at the focal point. The effect of the plate is to collimate the rf during transmit and focus it during receive, much like an ordinary optical converging lens.

geometry

To see how a Fresnel-zone plate works and to calculate the radii of the zones, refer to **fig. 2**. The outer edge of the nth zone is shown as R_n. According to the Fresnel diffraction theory, a wave that follows the path L-R_n-F arrives $n\lambda/2$ out of phase with a wave that travels the path L-O-F. To express this mathematically, we say:

$$(S_n + S_0) - (d_n + D_0) = n\lambda/2 \qquad (1)$$

With a little trigonometry we find that:

$$S_n = \sqrt{(R_n^2 + S_0^2)} \qquad (2)$$

and

$$d_n = \sqrt{(R_n^2 + D_0^2)} \qquad (3)$$

and using binomial expansion yields

$$S_n = S_0 + \frac{R_n^2}{2S_0} \qquad (4)$$

and

$$d_n = D_0 + \frac{R_n^2}{2D_0} \qquad (5)$$

Substituting into **eq. 1** yields

$$\left(\frac{1}{S_0} + \frac{1}{D_0}\right) = \frac{n\lambda}{R_n^2}\ , \qquad (6)$$

which is identical to the thin-lens equation so familiar in classical geometrical optics.

In this case the wave source at L is at some great distance from the point 0, thus the waves incident upon the zone plate are very nearly plane-wave in shape. Hence S_0 approaches infinity and **eq. 6** reduces to

$$R_n^2 = nD_0\lambda \qquad (7)$$

A more precise equation can be derived from more terms in the expansion, which results in

$$R_n^2 + D_0^2 = (D_0 + n\lambda/2)^2 \qquad (8)$$

Thus, the radius of the nth zone is given by

$$R_n = \sqrt{nD_0\lambda + \frac{n^2\lambda^2}{4}} \qquad (9)$$

From the principle of reciprocity, during transmit a point source at F would produce an almost plane wavefront on the opposite side of the zone plate. The system thus behaves as a collimating and focusing lens for transmitting and receiving respectively.

The dimensions for an experimental Fresnel-zone plate of ten zones, with a focal length of 100 centimeters at 10.4 GHz are given in **table 1**. Note that the area of each of the zones is constant, thus each zone will contribute equally to the sum intensity at the focal point. Suppose that we construct a zone plate that passes only the odd zones and blocks the

table 1. Dimensions for an experimental Fresnel-zone plate of ten zones with a focal length of 100 cm at 10 GHz.

radius of zone 1	17.0453 cm
radius of zone 2	24.1918 cm
radius of zone 3	29.7339 cm
radius of zone 4	34.4548 cm
radius of zone 5	38.6564 cm
radius of zone 6	42.4930 cm
radius of zone 7	46.0561 cm
radius of zone 8	49.4047 cm
radius of zone 9	52.5800 cm
radius of zone 10	55.6115 cm

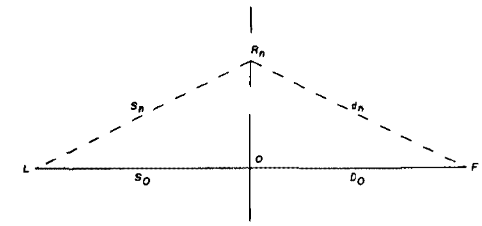

fig. 2. The Fresnel-zone plate is at *0*, the Gunnplexer is at *F*, and the contact station is at *L*. When the contact station is at a large distance (more than 10 wavelengths), the distance S_0 approaches infinity, and the rf wave at *0* appears as a plane wave.

even zones. The amplitude, *E*, at the focal point will be

$$E_T = E_1 + E_3 + E_5 + E \ldots + (2n-1) \quad \textbf{(10)}$$

If we construct a plate that passes the first 10 odd zones, the sum is $10\,E_1$. The incident wavefront gives $1/2\,E_1$, so the amplitude at the focal point, *F*, will be increased 20 times. The intensity is therefore increased 400 times, or 26 dB. Larger zone plates and greater gains are possible as long as the focal point aberrations are less than the depth of the Gunnplexer cavity.

construction

The first Fresnel-zone plate antenna I constructed was made from art matte board covered with aluminum foil and the radii cut out with a knife. Several "spokes" were left in the board to support the inner zones. Subsequent plates have been made with aluminum sheet metal. The resulting antenna has been tested with Doppler-shifted carriers and has confirmed the calculated focal length and gain.

It might be pointed out that modifications of the zone radii would make it possible to make a plate that was not flat and could thus be incorporated into the various shapes of aircraft or other vehicles. In either case, flat or otherwise, the dimensions required for a zone plate are not nearly as tight as those for a parabola, and the resulting antenna is much lighter.

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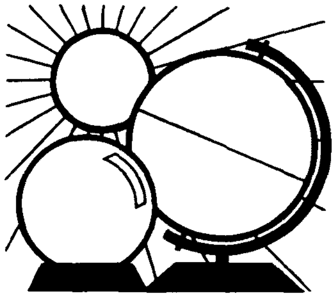


DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The first of the month is expected to favor the lower frequencies for nighttime DX activities. DX conditions for the upper-frequency bands should improve during the third week, then round off and drop during the end of the last week. Solar radio flux is expected to be high during that time. Propagation disturbances from solar-flare activity of two to three days' duration are possible around the 15th and 25th. Also, a disturbed period may occur around the 5th from a coronal hole. Conditions will generally be poorer for hearing and working DX during these disturbances, but look for unusual DX locations to appear with weak, fading signals.

The lunar perigee, of interest to moonbounce DXers, will occur on the 24th of this month. An Aquarid meteor shower, of interest to meteor-scatter DXers, will show a maximum between May 4th and 6th, with a rate of 10 and 25 per hour for the Northern and Southern Hemispheres, respectively.

sporadic-E propagation

One of the major paths for excellent DX signals in the summer is short skip, or multiple short skips, on the higher frequency bands. Here we are in May, nearing summer. The end of May heralds the beginning of the sporadic-E (Es) propagation season. Es is a thin layer of intense ionization about 60 miles (100 km) above the earth. It gives rise to strong, mirror-like signal reflections over the short-skip distance of 600 to 1200 miles (1000 to 2000 km). Signals remain strong from a half hour to a couple of hours on the average, as the name sporadic suggests, rather than all day long or all night as with other high-frequency propagation.

The highest frequency propagated by Es follows the sun across the sky; the highest probability of occurrence, however, is near sunrise and again around sunset. These two facets of Es affect short-skip openings differently. Openings on the higher-frequency bands occur near local noontime and the lower bands tend to have openings near sunrise and sunset.

Now look at the best locations for these Es openings: since Es is related to the summer sun, the effect is in the Northern Hemisphere from June through September and in the Southern Hemisphere during their summer, December through March. The best Es is on either side of the geomagnetic equator; it's especially good where the geomagnetic equator has greatest separation from the geographic equator. These special areas are Southeast Asia in the Northern Hemisphere and South America in the Southern Hemisphere. The first is the best of the two because the E region ionospheric electric currents are strongest there. Another location of prolific Es for short skip is the auroral oval at about 20 degrees around the geomagnetic pole. This Es is not a summer phenomenon, though; it's mainly equinoctial. During geomagnetic disturbances, particles from the solar wind entering the polar regions penetrate to the E and F regions producing ionization (aurora) there. It is associated with auroral scatter VHF openings which intrigue DXers who work east/west paths to Europe and Japan using this mode.

To look for Es openings on the higher-frequency bands, monitor beacons on 6, 10, and 15 meters, WWV frequencies, and CB channel 19. Also check TV channels 2 through 5 for 6- and 2-meter openings. The lower bands don't need beacon monitoring, since Es openings (sunrise and sunset) are available most nights. Remember: couple your antenna to the ionosphere with takeoff angles of 5-10 degrees (see the January, 1981, DX Forecaster).

band-by-band summary

Six meters will provide very good openings during high solar flux to South Africa, Australia, and New Zealand around local noontime. Look for possible Es short-skip by monitoring TV.

Ten, fifteen, and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day, either long skip to 2500 miles (4000 km) or Es short skip to 1250 miles (2000 km) per hop. The length of daylight is now approaching maximum, providing hours of good DXing.

Forty, eighty, and one-sixty meters are the night DXer's bands. On many nights 40 meters will be the only usable band because of thunderstorm QRN, but signal strengths via Es short skip may overcome the static when Es is available. Although Es is scarcely available in May, it should be better next month.

ham radio

MAY

WESTERN USA

GMT	PDT	N Asia Far East	NE Europe	E S. Africa	SE S. America	S Antarctica	SW New Zealand	W Oceania Australia	NW Japan
0000	5:00	—	20	—	15	10	10	10	15
0100	6:00	—	20	20	10	15	10	10	15
0200	7:00	—	20	20	10	15	10	10	15
0300	8:00	—	20	20	15	15	15*	10	15
0400	9:00	—	20	40*	15	15	15	15*	15
0500	10:00	—	20	40*	15	20	15	15*	20*
0600	11:00	—	20	40	15	20	15	15	20*
0700	12:00	20	—	20	20	20	15	15	20
0800	1:00	20	—	20	20	20	15	15	20
0900	2:00	20	—	20	20	20	15	15	20
1000	3:00	20	—	—	20	20	20*	15	20
1100	4:00	20	—	—	20	40	20	20	20
1200	5:00	20	—	—	20	40	20	20	20
1300	6:00	20	20	20	20	40	20	20	20
1400	7:00	20	20	15	15	40	20	20	20
1500	8:00	20	20	15	15	—	—	—	20
1600	9:00	15	20	15	10	—	—	—	20
1700	10:00	15	15	15	10	—	—	—	15
1800	11:00	15	15	15	15	—	—	—	15
1800	12:00	15	15	15	15	—	15	15	15
2000	1:00	15	—	15	15*	—	10	10	15
2100	2:00	—	—	—	15	—	10	10	15
2200	3:00	—	20	—	15	—	10	10	15
2300	4:00	—	20	—	15	10	10	10	15

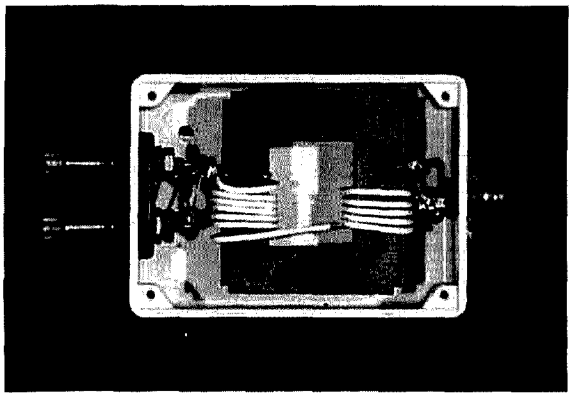
MID USA

GMT	MDT	N Asia Far East	NE Europe	E S. Africa	SE S. America	S Antarctica	SW New Zealand	W Oceania Australia	NW Japan	CDT
0000	6:00	—	20	15	15	15	10	10	15	7:00
0100	7:00	15	20	20*	15*	15	10	10	15	8:00
0200	8:00	15	20	20	15	15	15*	15	15	9:00
0300	9:00	15	20	40	15	15	15	15	15	10:00
0400	10:00	—	20	40	15	20*	15	15	15	11:00
0500	11:00	—	20	40	20	20	15	15	20	12:00
0600	12:00	—	20	20	20	20	20	15	20	1:00
0700	1:00	—	—	20	20	20	20	15	20	2:00
0800	2:00	20	—	20	20	20	20	20	20	3:00
0900	3:00	20	—	—	20	40	20	20	20	4:00
1000	4:00	20	—	—	20	40	20	20	20	5:00
1100	5:00	20	—	—	20	40	20	20	20	6:00
1200	6:00	20	20	—	20	—	20	20	20	7:00
1300	7:00	20	20	15	15	—	20	20	20	8:00
1400	8:00	20	20	15	15	—	—	—	20	9:00
1500	9:00	20	15	15	15	—	—	—	20	10:00
1600	10:00	20	15	15	15	—	—	—	15	11:00
1700	11:00	15	15	15	15	—	—	—	15	12:00
1800	12:00	15	15	15	10	—	15	—	15	1:00
1800	1:00	15	15	15	10	—	15	15	—	2:00
2000	2:00	—	15	—	10	—	15	10	—	3:00
2100	3:00	—	15	—	10	10	10	10	15	4:00
2200	4:00	—	20	—	10	10	10	10	15	5:00
2300	5:00	—	20	—	10	15	10	10	15	6:00

EASTERN USA

GMT	EDT	N Asia Far East	NE Europe	E S. Africa	SE Caribbean S. America	S Antarctica	SW New Zealand	W Oceania Australia	NW Japan
0000	8:00	15	20	15	15	20	15	10	15
0100	9:00	15	20	20	15	20	15	15*	20
0200	10:00	—	20	40*	15	20	15	15	20
0300	11:00	—	20	40	15	20	—	15	20
0400	12:00	20	20	40	20	20	—	15	—
0500	1:00	20	20	20	20	20	20	20*	—
0600	2:00	20	20	20	20	40	20	20	—
0700	3:00	20	20	20	20	40	20	20	—
0800	4:00	—	20	—	—	40	20	20	—
0900	5:00	—	20	—	—	40	20	20	—
1000	6:00	—	20	—	—	40	20	20	—
1100	7:00	—	20	—	—	—	20	20	20
1200	8:00	—	—	15	20	—	20	20	20
1300	9:00	20	—	15	20	—	20	20	20
1400	10:00	20	15	15	15	—	20	—	20
1500	11:00	20	15	15	15	—	—	—	—
1600	12:00	20	15	10	10	—	—	—	—
1700	1:00	15	15	10	10	—	—	—	—
1800	2:00	15	15	10	10	—	—	—	15
1800	3:00	15	15	15	10	—	15	—	15
2000	4:00	—	15	15	15	15	15*	15	20
2100	5:00	—	15	10	15	15	15*	15	20*
2200	6:00	15	15	10	15	15	15	15	15
2300	7:00	15	15	10	15	15	15	10	15

*Look at next **higher** band for possible openings.



another balun design

Discarded TV-set flyback transformer cores can be made into broadband baluns at minimal cost

Modern Amateur equipment is designed for unbalanced coaxial-cable output. The proper way to connect this gear to a balanced load, such as a dipole antenna, is to place a balancing network, or *balun*, between the coax transmission line and the antenna. The balun ensures proper operation of the antenna, prevents antenna currents from appearing on the coax-cable shield, and keeps rf voltages from appearing on the outside of the rig.

Theoretically, baluns can be constructed for any given impedance transformation, but standard transformation ratios are 1:1 and 4:1. The 1:1 balun transforms a 50-ohm unbalanced coax transmission line, for example, to a balanced 50-ohm load, or a 75-ohm unbalanced line to a 75-ohm balanced load. The 4:1 balun may be used to transform 300-ohm balanced line, such as twinlead, to a 75-ohm unbalanced coax line.

the flyback balun

Many balun designs have been described in the Amateur literature. The two designs presented here are in no way unique except in their use of ferrite cores from old TV-set flyback transformers.

Any discarded TV set has a flyback transformer (sometimes known as a horizontal-output transformer). This transformer, which has a ferrite core, is designed to operate at the horizontal sweep frequency of 15.75 kHz, and must handle harmonics extending to 1 or 2 MHz. The transformer is easy to disassemble, as the ferrite core is always in the form of two U-shaped halves. High-*Q* coils for low or medium frequencies can be made from this high-permeability ferrite, but in the upper high-frequency region, the core material is too lossy to form coils of any appreciable *Q*. This fact has probably deterred Amateurs from using these cores for baluns. (One exception is W6SJQ's article, "Three Baluns for a Buck," *73* magazine, August, 1979, page 102.) However, the baluns described here don't require high-*Q* ferrite cores for their performance. This is because, at high frequencies, the magnetic field does not penetrate very far into the core, so core losses remain small.

the 4:1 balun

Essentially, the 4:1 balun consists of a pair of two-wire transmission lines wound into coils as shown in fig. 1. The air-core version of this type of balun was known as "elevator coils" in the early days of television. Its operation can be understood if we assume for the moment that both lines are of 100-ohm characteristic impedance and without standing waves. Since the two 100-ohm lines are connected in parallel at the input, they will be matched to 50-ohm coax. At the output, however, the two 100-ohm lines are connected in *series* to produce 200 ohms, balanced to ground. The purpose of the ferrite cores is to give the bifilar coils enough inductance to isolate the input from the output and prevent a low-impedance path across the input or output terminals.

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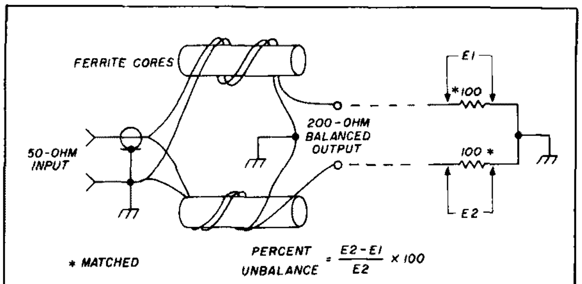

fig. 1. The basic 4:1 balun consists of two ferrite cores wound with 100-ohm (or 150-ohm) transmission lines. The air core version is known in the TV industry as "elevator coils." At the right is shown a method of determining the degree of unbalance at the output terminals by measuring the rf voltage across matched 100-ohm resistors.

The transformation of 75-ohm coax to 300-ohm twinlead ideally would require bifilar coils wound with 150-ohm transmission lines. Since neither 100- nor 150-ohm twinlead was available, the 4:1 balun coils were made with No. 24 (0.5 mm) vinyl zip cord. This wire is readily available in retail stores; often it is sold as "speaker wire." *Q*-meter measurements indicate its characteristic impedance to be about 156 ohms.

Vinyl, unfortunately, is quite lossy at radio frequencies. A better choice would have been twisted pair made of Teflon or polyethylene insulated wire. Ideally, the insulation should be of a thickness that give a characteristic impedance in the vicinity of 100 or 150 ohms, but below VHF the impedance is not particularly critical because the lines are short in terms of a wavelength. Another possibility is 72-ohm receiving twinlead.

Construction details are shown in the photograph. The size of the flyback transformer core is not particularly important; the one used here had a cross-sectional diameter of about 5/8 inch (16 mm). The two

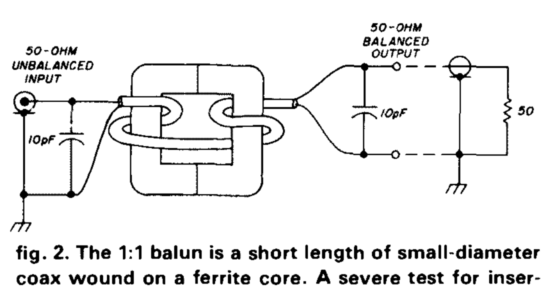

fig. 2. The 1:1 balun is a short length of small-diameter coax wound on a ferrite core. A severe test for insertion loss with this type of balun is to connect an unbalanced load the "wrong way" to the balanced output, as shown.

bifilar coils are twelve turns each; they should be wound in the same direction and should be as identical as possible. The coil ends can be anchored to the ferrite with epoxy cement. Leads to the input and output connectors should be short and of equal length for both coils. When wound, the two cores can be fastened to the wooden base by cementing the core faces to the wood with epoxy or super glue. If a metal box is used, the core faces should be spaced away from the metal by nonmetallic spacers of at least a few millimeters thickness.

1:1 balun

The basic design of the 1 to 1 balun, **fig. 2**, has been described previously by Joe Reisert, W1JR.[1] This is a "choke" type of balun: a magnetic core wound with small-diameter coax. Losses are very low in this type of balun, and it is ideal for connecting coax to a dipole antenna.

The toroidal ring is formed by cementing together the two U-shaped halves of the flyback transformer core. The coaxial coil is wound in two halves on opposite sides of the core; each half is six turns. Be sure to adhere to the winding direction shown in **fig. 2**. The ends can be secured to the core by tying with short lengths of nylon fishline.

The balun shown was wound with RG-196A/U 50-ohm coax; if 75 ohms impedance is desired, RG-187A/U is recommended. In either case, since the dielectric is Teflon rather than polyethylene, the power-handling capacity of this smaller coax is the same as RG-58 — about 400 watts at 30 MHz. For Amateur use this means the legal power limit below 30 MHz, because the duty cycle for CW is only 50 percent, and your kilowatt final is not going to exceed 80 percent efficiency. (Just don't hold that key down too long!) SSB has an even lower duty cycle. If RG-174/U is used the power rating will have to be reduced to 100 watts continuous at 30 MHz.

results

When the baluns were properly terminated, input SWR measured less than 1.1 on all bands, 160 through 10 meters. Measured insertion loss is given in **fig. 3**. Accurate measurement of insertion loss in the 1/10 dB area is never easy, but these curves are believed to be fairly accurate. The 4:1 balun has a power loss of 6.4 percent at 29 MHz. When 200 watts of rf were run through this balun, the zip cord became warm to the touch, revealing that the vinyl insulation was the cause of the power loss. Two hundred watts is about the maximum continuous power that the zip cord will handle at 10 meters, although higher power could be run intermittently, or at lower frequencies. As mentioned before, much better performance could be expected from Teflon-insulated

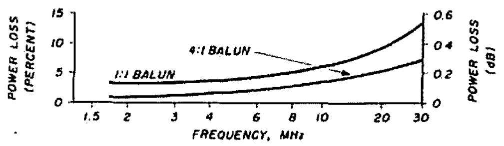

fig. 3. Measured insertion loss versus frequency for the two baluns. Percentage power loss is shown on the left hand scale, dB at right.

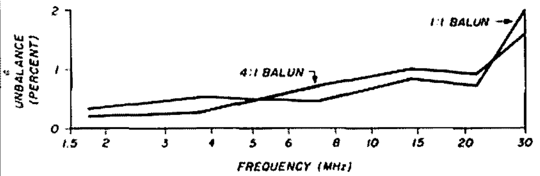

fig. 4. Measured percentage unbalance for the two baluns, measured across a balanced resistive load, as shown in fig. 1.

twisted pair. Insertion loss of the 4:1 balun measured 1 dB at 6 meters and about 3 dB at 2 meters.

The excellent results on 160 meters indicate that fewer turns could have been used on both baluns, which would reduce losses on the higher bands without much sacrifice of performance on 80 or 160 meters.

The 1:1 balun's insertion loss was measured by Joe Reisert's acid test; that is, by connecting the balanced output to an ordinary unbalanced-input wattmeter, with the *inner* conductor of the balun going to the *outer* conductor of the load, and *vice versa* (see fig. 2). As a result, most of the power loss shown in fig. 3 is radiation loss — not heat loss in the balun itself.

Initially the 1:1 balun showed an insertion loss of 3.5 dB on 2 meters. This high value was traced to reflections from the inductance of the half-inch-long leads that connect the RG-196 to the input and output connectors. The loss was decreased to 1 dB by soldering 10-pF capacitors, with the shortest possible leads, directly across the connectors.

Fig. 4 shows the degree of unbalance: $\frac{E2 - E1}{E2}$, expressed in percent and measured for both baluns by the split-load method shown in fig. 1. Two matched 25-ohm resistors were used for the split load on the 1:1 balun.

reference

1. Joe Reisert, W1JR, "A Simple and Efficient Broadband Balun," *ham radio*, September, 1978, page 12.

ham radio

antenna geometry for optimum performance

Design considerations in terms of path distance, ionospheric height, and antenna height

If you had your choice of a 10-dB-gain antenna at 40 feet (12 meters) or a 5 dB-gain antenna at 120 feet (37 meters), which would you choose? Presumably, there *would be a* split *decision on* such a question. However, the real reply would be that the question does not provide enough data to properly make a sound decision. Antenna gain or antenna height are secondary considerations in antenna design. *The primary objective in an antenna design is to provide maximum signal energy at the desired receiving location.* This is done by providing the most favorable radiation pattern in both the horizontal and vertical planes to match the conditions of a very unstable propagation medium, *the* ionosphere.

This article discusses the important relationship of the vertical radiation angle of an antenna, height of the ionosphere, and distance between the transmitter and the receiver. As to the opening question, it will simply be stated now that the high-gain antenna on 20 meters would be superior for domestic operations. The 120-foot (37-meter) low-gain antenna would always beat out the higher-gain antenna for maximum distance, world-wide contacts.

ionospheric reflections

High-frequency propagation occurs between the surface of the earth and one or more layers of ionized atmosphere that exhibit sufficient conductivity to reflect the radio signals back to earth. One reflection from the ionosphere is called one hop, and the number of hops made by the radio wave before arriving at the receiving location is the number of successive reflections from the ionosphere. These are called multihop transmissions. Single and multihop propagation can occur simultaneously.

Propagation *can be further* complicated by reflections from more than one conductive layer. **Fig. 1** is a simple flat-earth representation of a radio circuit showing reflections from the E, F_1, and F_2 layers of the ionosphere. Single-hop transmissions are shown by the solid lines and two-hop transmissions by a dashed line.

Consider the multiple path signals, both one and two hop, arriving at the receiver due to reflections from the E, F_1, and F_2 layers. Such a situation could exist if there is a broad vertical lobe of radiant energy from the transmitting antenna. The path length of the different signals, as well as the height change with time of the three layers, will cause the signals to arrive at the receiver at different times; that is, the signals will not all be in phase. Such a situation will cause fading of the received signal with loss in quality of the communications circuit.

One may eliminate the E-layer reflection completely by choosing a frequency high enough to penetrate the E layer at any vertical angle of radiation. If the frequency is close enough to the maximum usable frequency (MUF) and F_2 is controlling, then F_1 reflection may be absent, or very small. In such a case, the remaining conflicting wave arrivals would be from a one and two-hop reflection from the F_2 layer. How-

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ever, if it happens that the large angle of incidence at A and C of **fig. 1** caused the waves at these points to penetrate the F_2 layer without reflection, only the one-hop F_2 signal would arrive at the receiver at maximum strength with no fading. Elimination of the two-hop path could also occur by restricting the vertical radiation energy to a low angle of fire.

At the other extreme, the operating frequency could be chosen so low that the signal would not penetrate the E layer at all, thus eliminating the F_1 and F_2 reflections. However, there may remain multipath E-layer signals unless the antenna radiation patterns at transmitting and receiving locations provide very low response at the higher angles at which multipath E-layer signals could be propagated.

The known methods of attack on the multipath problem involve these factors:

1. Use a frequency that will cause reflection from one layer only, as nearly as possible.

2. Use a frequency that will require reflection at the lowest angle of incidence possible, such that higher angle radiations will penetrate the layer and not be reflected.

3. Use a directive antenna that will focus the angle of one dominant wave group and discriminate against other multipath signals by relatively low response to all other angles.

On one-hop circuits it might be relatively easy to apply any one or all three of the above principles for reducing multipath circuits. However, on multihop circuits different ionosphere characteristics occur at each point of reflection. Also it is necessary to use a frequency that is a limiting factor at one of the reflection points. Therefore, it is more difficult to adhere to those ideal principles for multihop paths.

is highest gain and height always best?

High antenna gain and high antenna height seem to be the dominant factor in today's selection of antenna systems. That philosophy without further thought to the overall consequences is all right if your goal is to put the strongest signal at the greatest distance at any particular time of the day. Don't be upset, however, if your signal is *less than average* at medium ranges during the daylight hours.

The strength of your transmitted signal received at a distant point, at any time of the day, is a function of your power, antenna gain, antenna height, atmospheric absorption factors, and the height of the ionosphere. Let's eliminate power, antenna gain, and absorption in the following discussion. Power and absorption are independent of the antenna system, and

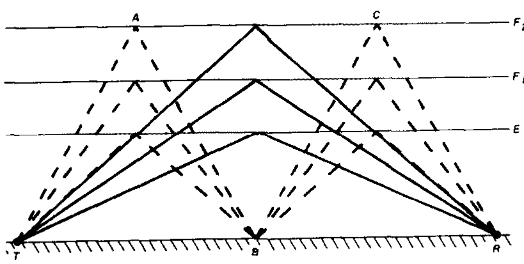

fig. 1. Flat-earth representation of a radio circuit showing reflections from the E, F_1, **and** F_2 **layers for a one-hop and two-hop transmission.**

the antenna gain, while important, does little good if the signal does not come down at the desired location.

the propagation-distance formula

The following equation relates the vertical angle of radiation from the antenna and the height of the ionosphere, to the distance between the transmitted signal and the point the signal returns to earth; that is a one-hop occurrence. (The derivation of the equation may be found in the appendix.)

$$D = 222.26 \left\{ \cos^{-1} \left[\frac{\cos \alpha}{(1 + 0.000157\, h_i)} \right] - \alpha \right\} \quad \textbf{(1)}$$

where D is the surface distance between the transmitting antenna and the first reflected return to earth in kilometers, α is the vertical radiation angle of the antenna in degrees from the horizon, and h_i is the height of the ionosphere in kilometers.

If you have a calculator with "*cos*" and "inverse *cos*" functions, the equation is easy to solve. However, **fig. 2** shows the equation pictorially for various heights of the ionosphere.

The use of the chart is quite simple. Enter the left side of the chart with the known vertical angle of radiation of your antenna. Go horizontally to the right until an intersection with a curve of the desired ionosphere height is met. Then drop down vertically and read the distance scale on the bottom of the chart.

Example. Known: Vertical angle of radiation is 30°. Ionosphere height is 400 km. Distance: 1206 km for one-hop transmission.

height of ionosphere

You say you don't know the height of the ionosphere or the vertical angle of fire of your antenna? OK, let's consider the ionosphere's height, and then we'll spend some time on the vertical radiation problem.

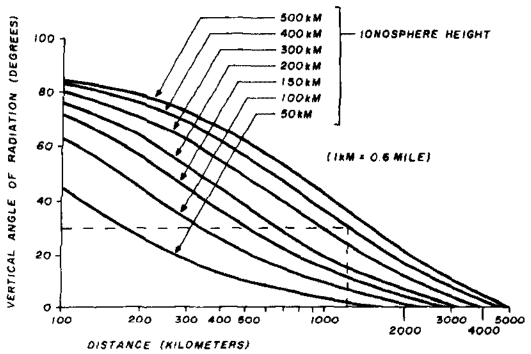

fig. 2. Vertical angle of radiation as a function of distance with ionosphere height as a parameter. An example is given for a vertical radiation angle of 30° and an ionosphere height of 400 km; the distance for a one-hop transmission is 1206 km.

The height of the ionosphere layers varies with latitude, with the hour of the day and the seasons, and with sunspot activity. Over the earth on any particular day, the variations of height are of the order of 2 to 1. Monthly average heights at any one location, however, usually follow a fairly constant pattern.

In some older texts, typical heights were assigned to the layers, but such rough information may be misleading. The Central Radio Propagation Laboratory, when at the National Bureau of Standards, Washington, D.C., used to publish monthly reports on details of various ionosphere heights, but that information has been discontinued. However, we do know the bands of ionosphere heights that will give us sufficient information to make our distance calculations; see table 1 for most intensely ionized regions. These bands of ionosphere heights will be used to show how the distance transmitted for a given vertical radiation angle changes from dawn to noon, for example, as shown in **table 1**.

vertical radiation angle

The vertical radiation angle of a horizontal antenna is easy to determine. Keep in mind that the vertical radiation of most horizontal antennas is a function only of its height above ground; this includes dipoles, Yagis, and other horizontally polarized, single-level beams. The number of elements in a Yagi, for example, does not change its vertical radiation angle. The radiation pattern in the vertical plane perpendicular to the wire of the antenna is given by the equation:

$$F(\alpha) = \sin (h \sin \alpha) \qquad \textbf{(2)}$$

where α is the vertical angle of radiation from the horizon

h is the height above ground in electrical degrees

The equation is meant for radiation over perfectly conducting ground. However, it is used for pattern work for typical imperfectly conducting grounds such as are encountered in practice.

The value of α for maximum signal at any given height, is when $F(\alpha) = 1$, since a sine function varies from a maximum of 1 to a minimum of 0. The latter factor, 0, means that there will be a null in the vertical radiation at some point.

The workable equation is (see the appendix for derivation):

$$h_{ft} = \frac{\sin^{-1} F(\alpha)}{0.366 f \sin \alpha} \qquad \textbf{(3)}$$

where: h_{ft} is the height of the antenna in feet

α is the vertical angle of radiation from the horizon for the antenna

f is in MHz

$F(\alpha)$ is 0 or 1, or as we will see later, any number in between such that $\sin^{-1}(1)$ is 90° for first lobe, 270° for second lobe, 450° for third lobe, etc., and $\sin^{-1}(0)$ is 180° for first null, 360° for second null, 540° for third null, and so on.

The solution of this equation with antenna vertical radiations of 90° to 1°, to give corresponding antenna heights for the first lobe at each frequency band, was done on a programmable calculator; doing it manually is a terrible job. Solution of antenna height was preferred over solving for vertical radiation angle because of the limits of 0° to 90° expected from an antenna pattern; antenna height can be from 0 to infinity theoretically.

The graph of the results is shown on **fig. 3**. That curve is very interesting so let's test it. You have your beam at an 80-foot (24-meter) level and are operating it on the 20-meter band. Enter the curve at the bottom for antenna height of 80 feet (24 meters) and go up vertically until you intersect the 20-meter antenna operating band. At that point go to the left horizontally and determine that the vertical angle of radiation for the antenna is 12.7°. The results for all Amateur bands for an 80-foot (24-meter) tower is shown in **table 2**.

table 1. Height of ionosphere.

layer	summer day (km)	winter (km)	night (km)
E	110 - 130	110 - 130	– –
F_1	280 - 310	210 - 250	275 - 325
F_2	450 - 480	270 - 320	– –

table 2. Vertical radiation angle for all bands with antenna height of 80 feet (24 meters).

frequency band (MHz)	vertical radiation angle first lobe (degrees)	first null (degrees)
1.90	(note 1)	—
3.80	54.0	(note 2)
7.25	25.0	58.0
10.25	17.5	37.0
14.20	12.7	25.5
18.10	9.8	20.0
21.25	8.2	17.0
24.94	7.0	14.2
28.50	6.2	12.5

(1) 90° is achieved by an antenna 136 feet (41.5 meters) high.
(2) 90° is achieved by an antenna 129 feet (40 meters) high.

Table 2 should be studied carefully by one-tower owners who like to "Christmas-tree" monobanders for different bands. Such towers usually have the 40-meter beam at the lowest height, then the 20-meter beam is higher, followed by the 15-meter beam, and the 10-meter beam on top. From a propagation standpoint, isn't that the reverse order? I always put the 40-meter beam on top to give it the lowest vertical radiation angle for the available height with the 10-meter beam on the bottom. The 10-meter beam automatically has a reasonable wavelength-height, hence a reasonably low vertical angle of radiation. It's the 40-meter beam that needs the highest location. That of course requires proper consideration for structural integrity.

For you 160-meter enthusiasts, **table 2** shows why a horizontal antenna on that band will be very poor for DX work. Even at 136 feet (41.5 meters) high, it is putting out a vertical radiation angle of 90°. Put your effort and wire into a vertical antenna for DX on 160 meters.

Although an 80-foot (24-meter) high antenna on 80 meters is probably better than the run-of-the-mill on that band, you will still do better with a properly constructed vertical for DX work.

vertical radiation null angle

The second consideration for the antenna height is, "Where are the nulls going to fall?" By making $F(\alpha) = 0$, such that $\sin^{-1} F(0) = 180°$, the first null can be determined. These values are also shown in **table 2**.

As you can see, **fig. 3**, showing the first lobe for all Amateur bands makes for a pretty busy graph. To show the additional lobes plus *nulls* would be a disaster. However, all bands for lobes and nulls up to the seventh is easily shown if height above ground is in electrical degrees. **Fig. 4** shows such a curve. To use the curve a calculation is necessary for the height and frequency for which you are interested (see the appendix for proof).

$$h = 0.366\, h_{ft} f \qquad (4)$$

where: h = height above ground in electrical degrees
h_{ft} = height in feet
f = MHz

Let's say you want to find the lobes and nulls for your 100-foot (30.5-meter) high tribander at 10, 15, and 20 meters. Solution of the equation for h for each band and subsequent use of **fig. 4** would give the results in **table 3**. You might ask the question, "Why bother about the null? There's nothing there anyway, so forget it!" There may be plenty "over there" where your signal is nulled out, and you should at least know about it even though you intend to ignore it. It may be just the knowledge you need to design for a different height or provide for a lower-height antenna to fill in the nulled area.

vertical radiation polar diagrams

Let's look at another representation of maximum (lobes) and nulls: the vertical polar radiation diagrams. See **fig. 5**, which is the 14.2-MHz plot of the 100-foot (30.5-meter) antenna. The same data is being used as in **table 3**. You have seen these in antenna books many times I'm sure. If you are like I am, you may have wondered how they determine their shape. Well, **fig. 5** was calculated and then plotted using the same $F(\alpha) = \sin(h \sin \alpha)$ equation as before.

All you do is select the height of the antenna you want, in feet, change that to electrical degrees, h, for the frequency desired, and solve the equation for dif-

table 3. Nulls/lobes for tribander at 100 feet (30.5 meters).

band (MHz)	height (electrical degrees)	radiation angle (degrees) first lobe		second lobe		third lobe		fourth lobe		fifth lobe	
		lobe	null	lobe	null	lobe	null	lobe	null	lobe	null
14.2	520	10.0	20	31	44	60.6	—	—	—	—	—
21.3	780	6.5	13	20	28	35.0	43	52	68	—	—
28.5	1043	5.0	10	15	20	25.5	31	37	43	50	58

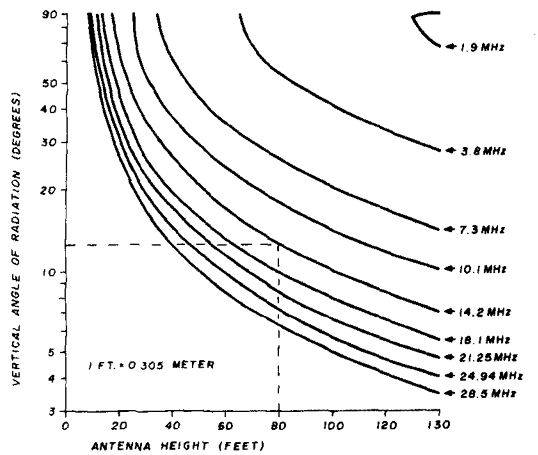

fig. 3. Vertical radiation angle as a function of height for horizontal antennas with frequency as a parameter. Example shows that an antenna height of 80 feet (24 meters) will produce a vertical radiation angle of 12.7° on the 20-meter band.

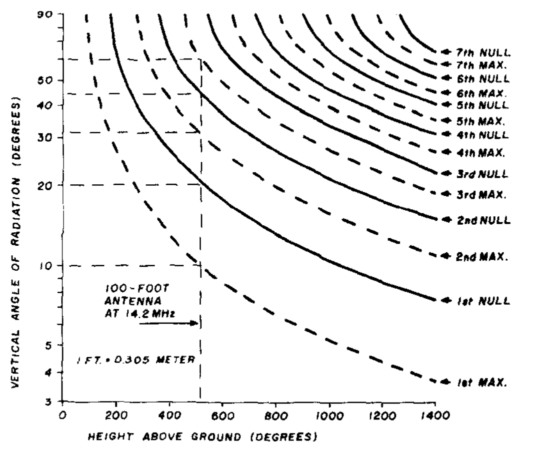

fig. 4. Vertical radiation angle as a function of antenna height in electrical degrees showing angles of maximum radiation and nulls for use on all bands.

ferent values of vertical angle of radiation, α, from 90° to 0°. This will give you the left side of the figure. If you use α equal to 180° to 0°, you get the complete radiation pattern for a dipole. However, one side is a mirror image of the other, and a beam antenna would be attenuated on the back side anyhow; use 90° to 0°.

These calculations are very easy using a programmable calculator when you program it to decrement automatically by 1°, 2°, 5°, or 10° steps from 90° or

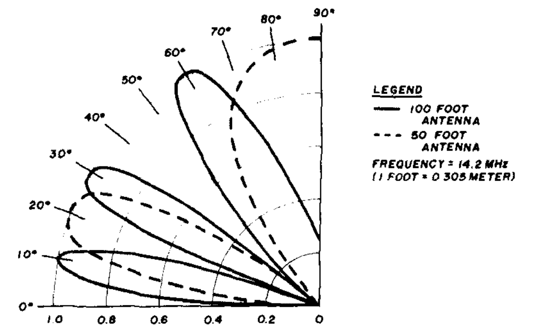

fig. 5. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled by the lower antenna (frequency is 14.2 MHz).

180° as desired; a printer would automatically list the results. For those with computers, a program could be derived to plot the diagram as calculations progress.

Examine **fig. 5**. It has three lobes and two nulls; the one at 90° is not a *full null*. Our lobes as shown pictorially there, and tabularly in **table 3**, are at approximately 10°, 31°, and 60°. An important null is at 20°. Why important? Twenty degrees vertical radiation from **fig. 2** with the ionosphere at 400 km, daytime F_2 layer height, is a good 1750 km hop.

From Cleveland, North Carolina, the distance to the heart of Germany is 7023 km, selected as being the center of a densely populated area. It so happens that 7023 km divided by 1750 km (the one-hop distance above) is exactly four hops. From **fig. 2**, the 10° signal gives a one-hop distance of 2650 km. Divide that number into 7023 and you will see it goes 2.7 hops. You can't have 2.7 hops, so you have to have 3 hops. Three times 2650 km is 7950 km. Therefore, the 10° vertically radiated signal lands almost 1000 km beyond the heart of Germany. However, if we had an antenna giving a 20° vertically radiating signal, it would be stronger than the 10° signal in that area when the ionosphere is at 400 km in height.

Referring back to **fig. 3**, you can see that a 20° vertical radiation can be obtained by an antenna height of 50 feet (15 meters). Superimpose this vertical radiation pattern on the vertical polar radiation diagram, **fig. 5**, to get a pictorial representation of how the 20° null is filled in by the 50-foot (15-meter) antenna. All vertical angles from about 6° through 36° are in excess of 80 percent of maximum signal. It is doubtful if you would want to use the 20-meter band for distances which 36° would provide — distances less than 1000 km one-hop.

Carry the analysis further to the 15- and 10-meter

bands with an antenna at 100 feet and one at 50 feet (30.5 and 15 meters); see **figs. 6** and **7**. On 15 meters, the lower antenna fills in the null at 15°, but leaves a null at the 28° vertical angle of radiation. That angle is good for about 1200 km; again a lower frequency would be better.

On 10 meters the same combination appears to be good from about 3° through 17° to give at least an 80 percent of maximum signal over that range. Again, vertical angles greater than 17° on 10 meters probably are not necessary except for sporadic E transmissions. The 100-foot (30.5-meter) antenna by itself would leave some undesirable holes in your vertical radiation pattern.

Those Amateurs with a computer can have a great time moving displays around to show the vertical pattern for a single antenna at different tower heights with a lower antenna to fill in the nulls.

exciting two antennas for greater gain

Of course, once you have two antennas at different heights, your next inclination is to say, "Why don't I excite both of them and get additional gain?". Good idea, but first you should know, "What is that going to give me in the way of vertical angle radiation?" A good question, and its solution is as simple as adding on a second term to the equation we've already been using.

$$F(\alpha) = N\,[\sin(h_1 \sin\alpha) + \sin(h_2 \sin\alpha)] \qquad \textbf{(5)}$$

See **fig. 8** for definitions of h_1, h_2, and α; h_1 and h_2 are in electrical degrees for the frequency being measured. N is a normalizing factor (makes *maximum* $= 1$) and may vary from one design to another. First run the equation from 90° to the lowest angle. You will see maximum lobe results greater than 1. To normalize the data, divide all results by the highest lobe results. That makes the highest results equal to 1, with a corresponding decrease in all other numbers. This is called "normalizing the data," and permits an easier comparison of different designs.

The calculator or computer solves the equation for given heights of h_1 and h_2 and varies the vertical angle α from 90° down to zero when programmed properly. Taking 5° steps works out well, but 1° steps may have to be taken at crucial points to determine the maximum point of a particular lobe.

Using the 50-foot and 100-foot (15- and 30.5-meter) high antennas at 14.2 MHz fed in phase and solving the $F(\alpha)$ equation produced the plot shown in **fig. 9**. The plots of **fig. 5** are superimposed on **fig. 9** to show the comparison pattern of each single antenna and together. The curve has been normalized (*maximum point* $= 1$) to compare its vertical angle with respect to the 50-foot and 100-foot (15- and 30.5-meter) curves. It may be seen that the maximum lobe for the combination is at 12°, with three attenuated ones at 38°, 53°, and 90°. A gain of 3 dB is realized in the horizontal plane with the combined antennas.

You may be interested in determining for yourself

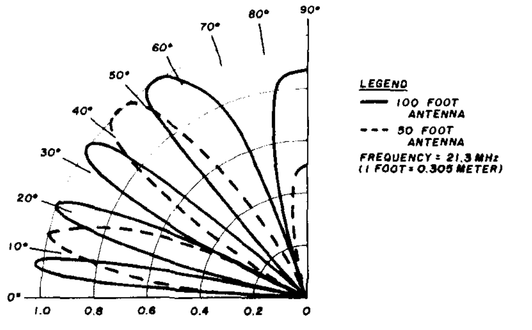

fig. 6. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled in by the lower antenna (frequency is 21.3 MHz).

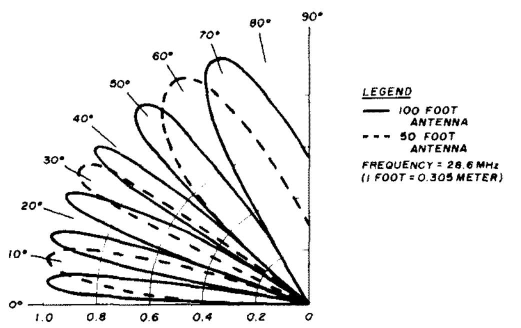

fig. 7. Vertical-polarization radiation diagram showing a comparison of the radiation pattern in the vertical plane of an antenna at 50 feet (15 meters) and one at 100 feet (30.5 meters). Nulls in the higher antenna may be filled in by the lower antenna (frequency is 28.6 MHz).

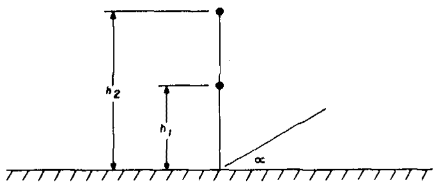

fig. 8. Definition of heights and vertical angle of radiation for two antennas excited in phase.

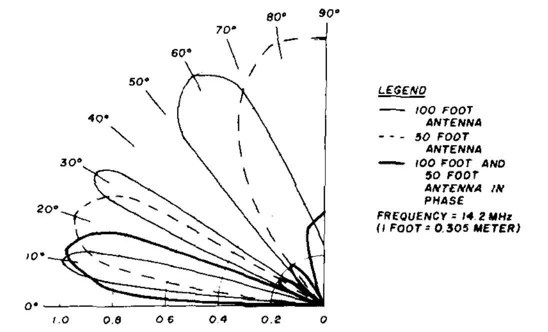

fig. 9. Comparison of the antennas of fig. 5 with the two antennas fed in phase to give an increase in gain in the horizontal plane. The pattern for the in-phase antennas has been normalized as explained in the text for comparison purposes.

what the pattern of half-wave spacing as well as 0.625-wavelength spacing would provide in the way of vertical radiation angles with height. The 0.625-wavelength spacing is the optimum spacing for maximum horizontal gain.

When striving for minimum vertical radiation angle, consider the following. **Fig. 2** shows that *if* the ionosphere were to attain a height of 500 km, the maximum one-hop distance would be 4850 km at 0° vertical angle of radiation. To attain a 0.1° angle of fire would require a horizontal antenna on 28.5 MHz to be at 4,944 feet (1508 meters) high. On 14.2 MHz, a 1° angle of fire would require an antenna at 992 feet (303 meters). So, do not expect to have horizontal antennas with a maximum lobe at 0°.

four-antenna array

As a final exercise for a 100-foot (30.5-meter) high tower, an array of four antennas spaced one-half wavelength apart for 15-meter operation was calculated. This is for the contester who wants to put a fixed array on the side of the tower for Japan, for example. The calculation is done using the same $F(\alpha)$ formula, but having four terms:

$$F(\alpha) = N\,[\sin(h_1 \sin\alpha) + \sin(h_2 \sin\alpha) + \sin(h_3 \sin\alpha) + \sin(h_4 \sin\alpha)] \qquad \textbf{(6)}$$

Fig. 10 shows the vertical signal to be expected. What a beautiful lobe with negligible high angle lobes, thus minimizing interference from short-haul stations. The vertical angle of about 8° produces about a 4-hop trip from North Carolina to Japan. If your 3-element Yagis were used, the horizontal gain would be 14 dB over a dipole. Sure beats a 12-element Yagi on a long boom for simplicity, and remember all the high-angle lobes you have to put up with using the single beam (refer to **fig. 6**).

conclusions

This article has attempted to point out the importance of designing an antenna system to put your signal where *you* want it to go. The variables under your control are the distance to your desired station and the height of your antenna. The variable not under your control is the height of the ionosphere. However, by judicious placement of secondary antennas in the vertical plane, you can effectively use changes in the height of the ionosphere and keep your maximum signal at a given receiver location.

Also, by knowing the vertical angle of radiation of your antenna you can determine proper height for short-haul contest work such as Sweepstakes, as well as long-haul DX contest or general DX work.

Although perhaps an over-simplification of the antenna problem, study of the multi-lobes of high antennas will show how "thin" the lobes are. Thus, changes in the ionosphere height will move the "footprint" of the transmitted signal into and out of your desired reception area more quickly than "fatter" lobes. Also, the multiplicity of lobes from the high antenna may result in multiple path fading problems, as explained earlier. Lower antennas and phased arrays have fatter lobes, hence a broader footprint, and will maintain their signal strength into their directed area for longer periods of time.

Ask yourself before investing in costly towers and antenna systems, "What are my antenna objectives?" Putting the signal into the area *you* want it to go still seems more important than putting the strongest signal wherever *it* wants to go. A study of your antenna objectives is not to be taken lightly!

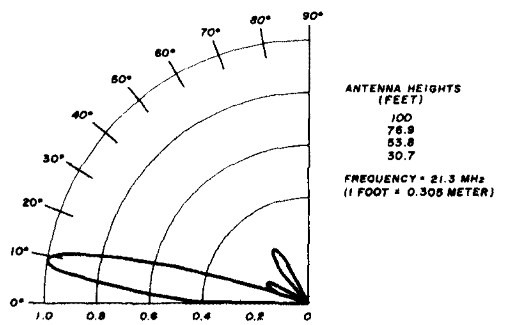

fig. 10. Results of feeding four horizontally polarized antennas in phase when stacked vertically to show elimination of extraneous major lobes (see fig. 6 for comparison). If three-element beams are used at each level, a 14-dB gain is realized in the horizontal plane.

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appendix

derivation of propagation-distance formula

Fig. A-1 shows a transmitting point at **A**, a reflection from the ionosphere at point **B**, and a one-hop return to earth at point **D**. The virtual height of the ionosphere is h_i, and the average radius of the earth, R_e, is a constant of 6,367.45 km. The intersection of the radius line from the center of the earth to its surface forms a right angle at point **A**. The vertical angle of radiation, α, is an angle that is added to 90° when determining angle CAB. The distance, **AD**, along any great circle on the surface of the earth is given by:

$D = R_e\theta$ when θ expressed in radians, or:

$$D = \frac{R_e}{57.296}\,\theta, \text{ when } \theta \text{ is expressed in degrees.}$$

The problem is to find a relationship of θ with respect to α and h_i and involves the triangle $CABC$. Two sides of that triangle are known: $BC = R_e + h_i$, $CA = R_e$. *Angle CAB* is known: *angle CAB* $= 90° + \alpha =$ *angle A*.

Knowing two sides and one angle, the other side and angles may be determined from the law of sines.

solution of problem by law of sines

The law of sines says, given A, a, and b (see fig. **A-1**):

$$\text{Angle } C = 180° - \text{Angle } A - \text{Angle } B$$

$$= \text{Angle } BCA = \frac{\theta}{2}$$

Also, $\frac{b}{\sin B} = \frac{a}{\sin A}$, thus $B = \sin^{-1}\left(\frac{b \sin A}{a}\right)$

and $C = 180° - (90° + \alpha) - \sin^{-1}\left(\frac{b \sin A}{a}\right)$

Replacing the above with our own symbols:

$$\frac{\theta}{2} = 180° - (90° + \alpha) - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$$

$$\frac{\theta}{2} = 90° - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right] - \alpha$$

But $\sin(90° + \alpha) = \cos\alpha$

and $90° - \sin^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$

$$= \cos^{-1}\left[\frac{R_e \sin(90° + \alpha)}{R_e + h_i}\right]$$

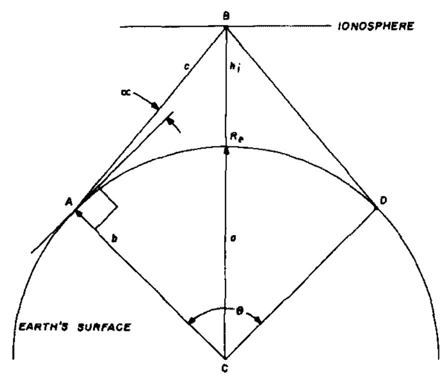


fig. A-1. Geometry for derivation of propagation-distance formula. Signal leaves the earth's surface at an angle, α is reflected from the ionosphere at point *B*, and returns to earth at point *D*.

Therefore, $\theta = 2\cos^{-1}\left[\frac{R_e \cos\alpha}{R_e + h_i}\right] - \alpha$

Knowing θ, we can now solve for D, and cleaning up the $\cos^{-1}$ term, we get:

$$D = \frac{2R_e}{57.296}\left[\cos^{-1}\left(\frac{\cos\alpha}{1 + \frac{h_i}{R_e}}\right) - \alpha\right]$$

but $R_e = 6{,}367.45\ km$

Therefore:

$$D = 222.265\left[\cos^{-1}\left(\frac{\cos\alpha}{1 + .000157h_i}\right) - \alpha\right] \text{ kilometers}$$

height-in-feet equation

We start with the given equation:

$$F(\alpha) = \sin(h \sin\alpha)$$

We wish to change h, which is in electrical degrees to h_{ft}, which is the height of our antenna in feet above the earth's surface.

We know that $1\lambda = 360°$. Therefore the fractional part of a wavelength (any antenna height) is the ratio of actual antenna height in feet to λ in feet times 360°.

$$h = 360°\,\frac{h_{ft}}{\lambda_{ft}} \text{ degrees, but } \lambda = \frac{984}{f_{MHz}} \text{ feet}$$

$$\text{so } h = \frac{360}{984} f_{MHz}\, h_{ft} = 0.366 f_{MHz}\, h_{ft} \text{ in feet}$$

We can say:

$$F(\alpha) = \sin\left[(0.366 f_{MHz}\, h_{ft}) \sin\alpha\right]$$

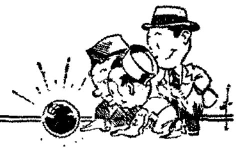
$$\sin^{-1} F(\alpha) = 0.366 f_{MHz}\, h_{ft} \sin\alpha$$

Therefore:

$$h_{ft} = \frac{\sin^{-1} F(\alpha)}{0.366 f_{MHz} \sin\alpha}$$

ham radio

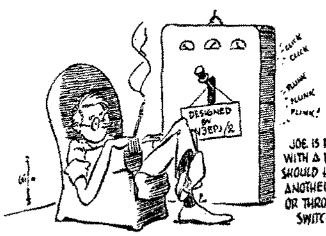
THE CRYSTAL BALL



ON OR OFF?

From the articles printed in the Crystal Ball it is evident that most of the brethren have their mental machinery running at prewar speeds. Don't they realize that we have entered upon a new era of rockets, A-bombs, robots, and fungicides? Why hack around with these pitiful pseudo-modern ideas for the new Ham Station? Here is a plan for a rig combining simplicity and ease of operation.

First let us examine the fundamental requirements of an ideal amateur station. The primary question confronting the average ham is: does he want his station *on* or does he want it *off*? Reference to the literature will confirm that an "on-off" switch is the most practical solution to this problem. Having established this component as a prerequisite, let us delve into the less-interesting sub-assemblies to be tied into the on-off switch. The best way to cover this is to describe the sequence of operations occurring when this switch is thrown from the "off" to the "on" positions.



JOE IS FACED WITH A DECISION - SHOULD HE HAVE ANOTHER QSO -- OR THROW THE SWITCH ?

Joe Blow strolls into his shack, turns on the aforementioned switch, lights a cigarette, and starts reading the latest copy of *Esquire*. Rotating beam antennas on all amateur bands start scanning the horizon, feeding in signals to appropriate receivers, which are scanning the bands in frequency, looking for a CQ. Let us suppose that the receiver system on band A finds a CQ first. The audio signal, having passed through the CQ-pass filters operates relays which deenergize the other receivers, switch off the scanning function of antenna A, and automatically point the beam at the originating transmitter by means of an appropriate servo system. *Simultaneously*, Joe's own transmitter is automatically tuned to the frequency of the incoming signal, and held in readiness to transmit. As soon as the received signal stops, the transmitter sends out a call automatically prepared on a magnetic wire recorder *from the call sent by the* other station and including Joe's call.

Whenever the other station breaks in, Joe's transmitter stands by and his receiving system comes into its own. Basically, the signal is fed into three channels, the Log Channel, the QSL Channel, and the Miscellaneous Channel. The Log Channel uses information contained in the signal relating to the signal strength and the time the QSO started, and prints it on the Log Sheet. The QSL Channel, in a similar manner, prints part of the QSL card. The Miscellaneous Channel accumulates the non-essential information passed out by the other station and feeds it into the waste basket. It also performs the very essential function of taking the signal report given, running it through a computer coordinating distance, number of previous QSO's, and blood pressure of Brother Joe in calculating a weighting formula to be applied to the otherwise accurate RST report to be given back to the distant station.

When the victim stands by, Joe's station automatically goes to the transmit position, sends out "Good Morning," "Good Evening," or "Good Afternoon," as determined by a suitably-connected clock, transmits the other fellow's RST report complete with fudge factor, gives the weather as measured by a barometer and thermometer on the roof, states the QTH (not a variable, making this part simpler), adds 73 and signs.

After the other station signs, the Log and QSL machines finish printing their respective cards. When this is complete and the QSL card has been automatically shot out to the nearest mail box, the second-hand air raid siren is energized to distract OM Blow from his *Esquire*. He is then faced with a decision. Should he let things take their course and have another QSO, or should he throw the switch to "off" and delve further into the printed pulchritude?

Carl C. Stotz, W3EPJ/2

Thanks to the ARRL for permission to reprint this column by Carl C. Stotz, W3EPJ/2 from the February, 1946, issue of QST.

ham radio TECHNIQUES

Bill Orr W6SAI

It is difficult to prophesy, especially with respect to the future. — Bob Booth, W3PS (Silent Key).

What will Amateur Radio be like in 2015? Will there be Amateur Radio in thirty-three years from now? Interesting questions, to be sure.

Reprinted from *QST* is a tongue-in-cheek prediction of Amateur Radio's future as seen from 1946. Is our vision of the future as clear as this one, written before the days of transistors, ICs, and computers?

Looking into the cloudy crystal ball, I see Amateur Radio flourishing in 2015 but in a far different form than the hobby of today.

- In 2015, all the computers, communications equipment, and data storage systems you see today will be obsolete museum pieces.
- By 2015, great advances in fiber-optic transmission will make cable communications and most radio communications over fixed, short distances obsolete.
- In 2015, long-distance communications will be exclusively by complex, wideband, high-power satellites and land-based repeaters.
- Radio transmission via the ionosphere, an unreliable medium at best, will be obsolete. VHF satellite repeaters and fiber-optic cables will replace them. *Radio, television, and fm broadcast stations as we know them today will not be in use in 2015; they will not be needed.*
- Home computers, tied into large computer networks around the world, will be commonplace. Information and entertainment will be available on a three-dimensional color screen in most homes.
- It will be possible to call up any of thousands of information channels at will — including direct communications with other computer terminals — worldwide.

why, then, Amateur Radio?

As a consequence of the information explosion and instant communications available in 2015, radio transmission in the medium- and high-frequency spectrum will be obsolete, except for some military purposes (over-the-horizon radar, the Woodpecker, for example), scientific studies, and Amateur Radio communications. All else will be transmitted by other, more reliable, means.

Radio Amateurs will not be restricted to bands in 2015. They will roam freely the entire high-frequency spectrum. And more. Amateurs will work alongside the few users of the radio spectrum over a frequency range of 500 kHz to perhaps 75 MHz. This is how it will be done.

the ham station of 2015

The Amateur station of the future will consist of a broadband transmitter, receiver, and antenna, computer controlled and capable of frequency-agile transmission at any point in the radio spectrum. Let's suppose Our Hero has one of these marvelous devices and wishes to make contact with another Amateur station.

The computer terminal is energized and a propagation display appears on the screen, derived directly from the International Weather Service through the optic-fiber communications line running into the home. Looking at Europe on the map, Our Hero decides it would be nice to have a chat with a German or French Amateur. He keys his instructions into the computer. Instantly his transmitter is armed with the proper data. It transmits a coded signal (similar to the CQ of olden days) that jumps about in frequency in a sequence selected by the computer that continually sweeps to interrogate the Maximum Usable Frequency (MUF) over the chosen path. Frequency agility is rapid, the signal remaining on any one spot for less than a second. To a casual observer, looking over the range of frequency spotting, *no signal is apparent*. To another observer, however, who has received the coded transmission and keys his equipment up in response to this code, an interference-free signal is received that contains the data needed to transmit a reply in the same coded sequence as that received.

Our Hero, then, has keyed in a frequency agility code, as well as codes that select the region of the earth (or country) to be scanned by his receiving computer. All this information appears on the video screen of his equipment.

The signal is ignored by all stations except those whose computers are programmed to search for the particular code Our Hero is using. Once a code match is established, the second ("reply") station alerts the first ("search") station that it is in lock. The search station may jump about in frequency to dodge interference, but its continually transmitted coding signal forces the reply station to follow it to the exact Hertz!

the QSO

Now that the two stations are completely in lock, the contact can run until the Maximum Usable Frequency falls below the critical cutoff frequency at which signals are lost on the particular path. Continuously listening to each other, the computers instantly shift frequency at will, seeking a clear channel for QRM-free communications.

Our Hero can now choose *his* mode of communications. Voice? Slow-scan digitized television? Practice CW? Or radio-teletype? Perhaps transmit some music? Why not? He can copy by ear, watch it on a video display, or record it on a form of tape for playback. Or he can do all of these at once.

While the QSO is in progress, giant Woodpecker transmitters used for ionospheric-reflected information gathering roam about the high-frequency spectrum. They, too, by international agreement are frequency-agile, perhaps transmitting only one pulse on a given frequency before moving on, continuously sensing the transmitting frequency for an existing signal before transmitting their powerful pulse.

Intermixed with the Woodpeckers are other forms of pulsed transmissions for military and scientific purposes. And dodging about in this signal mix are the Amateur signals. All services interrogate frequency after frequency until an open spot is found — then *zip*! the pulsed information is sent and retrieved and the transmitter moves on once again.

Listening to this frequency-agile, frequency-hopping, computer controlled mode of transmission on an ordinary receiver would reward the listener with only a random hum, or loud background noise. No intelligence would be apparent. But a locked "reply" station would instantly sift through the myriad signal bits and accept only those bits that its coded memory recognizes.

Armed with propagation information and a "callbook" of the transmission identification codes used by other Amateurs, Our Hero can quickly program his station to search for a single unique signal, or one group of signals *among* a family of signals, or any random signal the computer may process in a frequency search. Sometimes it might be fun to speak at random to any station caught during the computer search. And other times a certain station or region may be pinpointed for specific QSOs.

At any given time, tens or hundreds of Amateur stations would be scanning the high-frequency spectrum, either in search or reply mode. If Our Hero desires, each station scanned would pop up on the video screen, showing its individual coded signal (the equivalent of the call letters of half a century earlier). Our Hero can either pick out a contact as the codes pass across the screen or he can instruct his computerized receiver to pick the contact for him. Or he can project himself into the ether with his own coded signal, and wait until another Amateur station locks onto his coded series of pulses. Automatic or manual coded search is available at the touch of a button.

the station library

Once contact is established instant break-in is available, regardless of the communication mode chosen. Bandwidth can be tailored to fit the job at hand. If voice is chosen, the voice is converted into digital signals and reconverted back into speech at the receiving station. Each station will have a memory library tape of thousands of words and the computer will automatically translate one language to another provided the correct coded language information is sent along with the voice. While the Amateur's computerized vocabulary may be limited to perhaps 5,000 words or less, and his sentences may be somewhat constricted by the limited vocabulary of his equipment, a plain language QSO is possible, with each Amateur speaking *his* own native tongue. The computers will do the rest.

If it is desired, a digital printer will reproduce the QSL card, or photograph of the station, for instant printout at the other end. Or a video camera may be cut in for a slow scan picture of station and operator.

At the same time, Our Hero can be in contact with a local VHF repeater (or translator), which can bring in other interested parties to the QSO. These other Amateurs may be on various VHF bands, with simplified equipment that can transmit a signal capable of *being* translated to a high-frequency, computer-controlled station capable of worldwide communications. Perhaps the high-frequency station is a remote site, located on a commanding hilltop QTH and operated by club members who access the equipment with a private code. Thus the apartment-bound Amateur can achieve worldwide communications through a mini-watt control console that fits on a corner of his desk, or atop his 500-channel, three-dimensional color television receiver and stereo system.

Amateur licensing in 2015

Amateur Radio, like other forms of communications in 2015, is under the control of the Department of Communications, which replaced the antiquated Federal Communications Commission in 1986. The General class license costs ten "new" dollars, the new dollar being equal to one hundred old dollars (which were withdrawn from circulation in 1996 when their real value had depreciated to almost nothing).

The license, good for a lifetime, authorizes the Amateur operator to run up to 5 kW steady state or 50 kW peak power at a repetition rate of less than 10 microseconds. All operating frequencies between 500 kHz and 100 MHz are authorized. Mode of transmission is not specified. The license exam requires a knowledge of the international communications laws (the licensee must pass a simple exam, somewhat akin to the written portion of the *driver's license test*). *There is* no technical requirement, as Amateur equipment is too complex to work on

or modify, and all operation and maintenance instructions are provided in a video tape supplied with the equipment and are further encoded in the computer. Since the Morse code is an outmoded form of communications, employed only by eccentrics, no code test is required.

As of 2015, there are over 40 million General class Amateur licensees in the United States, with an equal number scattered over the globe. Even so, with modern communications techniques, interference between Amateurs is at a minimum.

the VHF Amateur license

The highest grade Amateur license in 2015 is the VHF license, which permits operation above 100 MHz and includes satellite operation. A complex technical examination is required for this license. Only 550,000 such licenses exist in the United States.

The VHF Amateur has access to over one hundred high power, repeater style, synchronous satellites, plus the ten active repeaters on the surface of the moon and the three repeaters on Mars. With this galaxy of repeaters at his command, the VHF Amateur can talk to any spot on earth with a simple, ten-thousand channel hand-held VHF transceiver. In addition, he can talk with the hams stationed at the Moon Base (Luna One) and, at times, the hams on the first expedition to the moons of Jupiter and Saturn. He is also licensed for point-to-point earth VHF communications using various exotic modes of propagation.

the genesis of the 2015 ham station

For most of the twentieth century, high frequency communications were linked to limitations in frequency generation. At first, crystal control was used on discrete channels. Later the variable-frequency oscillator provided some limited flexibility over narrow bands. Thus, because of the rigid frequency-generation scheme, a complete legal and technical system was built up to control spectrum use. This led to the adoption of narrowband antenna systems for the frequencies assigned.

In the late fifties and early sixties, frequency synthesis became a practical reality, making possible high-frequency transmitting/receiving equipment capable of easily and rapidly tuning to any spot in the high-frequency spectrum. This revolutionary technique was inhibited by a regulatory process based upon decades of control built around an outmoded channelized, or "band assignment" concept. With the elimination of the Federal Communications Commission and the establishment of a new regulatory body that had expertise in "adaptive high frequency use," a new world of communications was opened for Radio Amateurs.

The new communications technique obviated frequency bands, heretofore thought sacrosanct. The new philosophy was to use low power equipment to sweep through the entire high-frequency range and to measure and log all propagation characteristics and interference, without indicating what frequency, or frequencies, would ultimately be used for communicating. Communications with a coded station could be established on any part of the high-frequency spectrum that would support a reliable radio path. Multiple transmission on two or more frequencies at one time, or sequential transmissions on multiple frequencies, was the powerful tool used to achieve reliable communications. Rapid frequency-hopping transmissions, moreover, eliminated the need for Service Assignments, so jealously guarded in the closing days of the late nineties. The old administrative limitations on spectrum occupancy were swept out with a convulsive, international conference, and new regulations were set up to reflect the modern technological revolution.

And thus Amateur Radio grew and prospered in the early years of the twenty-first century!

ham radio

HAM CALENDAR

May

SUNDAY | MON | TUES | WED | THUR | FRI | SATURDAY

Saturday 1

ARRL INTERNATIONAL EME COMPETITION — 1-2.

QUANNAPOWITT RADIO ASSOCIATION HAMFEST — South Hall Fire Station, corner of Salem and Summer Streets, Lynnfield. Contact KA1MI — 1.

SOUTHERN TIER ARC 23RD ANNUAL HAMFEST — Oswego Treadway, Oswego, NY. Contact Craig England, KF2X — 1.

YAKIMA ARC ANNUAL HAMFEST — Ahtanum Youth Activities Park, Yakima, WA. Contact Dave Pankey, N7BRB — 1-2.

BRISTOL, JOHNSON CITY & KINGSPORT ARC 2ND TRI-CITIES HAMFEST — Appalachian Fairgrounds, Gray, TN. Contact Tri-Cities Hamfest, POB 3682 CRS, Johnson City, TN 37601 — 1-2.

COUNTY HUNTERS SSB CONTEST — 1-2.

W1AW Schedule

October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily
W1AW code practice and bulletin transmissions are sent on the following schedule:

EST	Slow Code Practice	MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	RTTY Bulletins	Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M.
	Voice Bulletins	Dy: 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M.
	Fast Code Practice	MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M.
	CW Bulletins	Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M.
	Voice Bulletins	Dy: 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M.
	Fast Code Practice	MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

2

FIFTH ANNUAL P.V.R.A. FLEA MARKET — George Penny H.S., East Hartford, Exit 91 off I-86. Contact K1NFE — 2.

CENTRALIA WIRELESS ASSOCIATION'S ANNUAL HAMFEST — Kaskaskia College Gym, 3 miles NW of Centralia. Contact Bud King, WB9QEG — 2.

AMATEUR RADIO FLEA MARKET — sponsored by the New England Amateur TV Group, Freeport Hall, Dorchester. Pre-register by April 25th to NEAT, POB 406, Boston, MA 02102 — 2.

TRI-COUNTY RADIO ASSOCIATION'S HAMFEST/FLEA MARKET Passaic Township Youth Center, Valley Rd., Stirling, NJ. Contact Herb Klewunn, W2CHA, 201-647-3461 — 2.

LYNCHBURG ARC ANNUAL SWAPFEST — Brookville H.S., Route 460 west of Lynchburg, VA. Details via POB 4242, Lynchburg, VA 24501 — 2.

3

GEORGIA QSO PARTY — 1-3.

WEST COAST BULLETIN — 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM — 3

4

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)
AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

5

6

7

HAMPDEN COUNTY RADIO ASSOCIATION'S ANNUAL FLEA MARKET — Feeding Hills Congregational Church, Routes 57 & 187, Feeding Hills, MA. Contact Larry Langevin, K1GXU — 7.

INDIAN RIVER ARC — "Sun Day" operating on W4NLX 4 on 1300-1400 GMT, 40 meters, 7250 to 7275 kHz SSB, 1400-2000 GMT, 15 meters, 21350 to 21375 kHz SSB. For more information contact Florida Solar Energy Center "Sun-Day," 300 State Route 401, Cape Canaveral, FL 32920 — 7-8.

8

USSR "CQ M" CONTEST — 8-9.

ARROWHEAD RADIO AMATEUR CLUB'S ANNUAL SWAPFEST — At First United Methodist Church, 230 East Skyline Pkwy., Duluth, MN. Contact Jerry Frederick, N0BNG — 8.

OZAUKEE RADIO CLUB'S 4TH ANNUAL SWAPFEST — Circle B Rec Center, Highway 60, Cedarburg, WI. Contact Ozaukee Radio Club, POB 13, Port Washington, WI 53074 — 8.

GREATER FAIRFIELD ARA SPECIAL DOGWOOD FESTIVAL QSO PARTY — Members of the club (W81COO) will be on six Amateur Bands to explain the festival. 1300-2200 UTC or 9 AM to 6 PM EDST. SSB Frequencies: 3975, 7235, 14330, 21420 and 28710 MHz. FM 146.55 simplex. Contact KA1JT with SASE for QSL — 8.

PUTNAM EMERGENCY AMATEUR RADIO LEAGUE'S FIRST ANNUAL HAMFEST — JFK Elementary School, Foggintown Rd., Brewster, NY. Contact Frank Konecnik, WB2PTP — 8.

9

10

W1AW QUALIFYING RUN — 10

11

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)
AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

12

HOLLAND ARC will operate K8DA with other participating stations during Netherlands American Bicentennial during Tulip Time. Operations on all phone bands and some CQ. QSL to HARC, POB 92, Zeeland, MI 49464 — 12-16

13

14

EIGHTH ANNUAL EASTERN VHF UHF CONFERENCE — Sheraton Inn and Conference Center, Boxboro, MA. Contact Rick Commo, K1LOG — 14-16

15

MICHIGAN QSO PARTY — 15-17.

FLORIDA QSO PARTY — 15-16

ROCKINGHAM COUNTY ARC will operate from Cape Hatteras Lighthouse. Operating frequencies: 30 Kc up from bottom of general portion of each band, phone and CW — 15-16

NORTHWEST ARKANSAS ARC 2ND ANNUAL HAMFEST/SWAP-MEET — Community Bldg., Rogers on US Hwy. 71. Contact Marv Webb, KA5HEV — 15

DURHAM FM ASSOCIATION'S ANNUAL DURHAMFEST — South Square Mall, U.S. 15-501 south. Contact Durhamfest, Box 777, Hillsborough, NC 27278 — 15

16

YAKIMA ARC, W7AQ — Special event station for anniversary of Mt. Saint Helens eruption. 1800 May 16th to 0200 May 17th UTC. Frequencies will be 25 kHz up from bottom of General phone edge; CW up 25 kHz from Novice band edge and at 14.060, all + QRM and band conditions. QSL available by SASE to W7AQ — 16-17

INDIAN FOOTHILLS ARC 7TH ANNUAL HAMFEST — Saline County Fairgrounds, Marshall, MO. Contact Jim Little, KB0DA — 16

WARMINSTER ARC ANNUAL HAMFEST — Middletown Grange Fairgrounds, Wrightstown, PA. Contact Bill Scott, KA3CHB after 6 PM (215) 249-0568 — 16

EASTON ARS 8TH ANNUAL HAMFEST — Easton Sr. H.S., Easton, MD. Contact Van Herridge, W83HGO — 16.

WABASH COUNTY ARC'S 13TH ANNUAL HAMFEST — Wabash County Fairgrounds, Wabash, IN. Contact Dave Spander, N9ADO

TRI-STATE ARS ANNUAL HAMFEST — Vanderburgh County 4H Center, Evansville, IN. Contact Hal Wilson, WB9FNN — 16.

17

WEST COAST BULLETIN — 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM — 17

18

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AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

19

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21

WIESBADEN ARC 7TH ANNUAL DXPEDITION TO LIECHTENSTEIN — Callsign DA1WA/HB0. CW, Phone and RTTY, all the frequencies 10 to 160 meters. CW operations for American stations will be attempted at 3.725 and 21.120 MHz between 1900 and 2100 EST. Send SASE to S. Hutchins, POB 4573, APO New York 09109 for QSL — 21-30

FRESNO ARC 40TH ANNUAL HAMFEST — Hacienda Inn, Clinton & Hwy 99, Fresno, CA. Contact Fresno ARC, POB 783, Fresno, CA 93712 — 21-23

22

SOUTH SHORE REPEATER ASSOCIATION'S ANNUAL HAM RADIO/ELECTRONIC/COMPUTER FLEA MARKET — South Weymouth H.S. Cafeteria. Contact SSRA, David Newman, POB 447, Abington, MA 02351 — 22

PORTLAND AMATEUR WIRELESS ASSOCIATION & SOUTHERN MAINE UNIVERSITY RADIO CLUB — Annual Flea Market, Gorham, Maine, campus. Contact John Taylor, N1SD — 22.

ARRL DELTA DIVISION CONVENTION & 16TH ANNUAL KNOXVILLE HAMFEST — Bearden H.S., 8352 Kingston Pike, Knoxville, TN. Contact Raymond Adams, N4BAO — 22-23.

CLARK COUNTY ARC 2ND ANNUAL MT. SAINT HELENS QSO PARTY — Frequencies: SSB: 3805, 7230, 14280, 21360, 28505. CW: 3705, 7105, 21105, 28105. VHF: Various Vancouver and Portland area repeaters. For QSL send to Award Manager, W7AIA, POB 1424, Vancouver, WA 98778 — 22-23

ANDERSON, HARTWELL & TOCCOA ARC ANNUAL HAMFEST — Lake Hartwell Group Camp, Hwy. 29, Lake Hartwell, GA. Contact Ray Pettit, WB4ZLG — 22-23.

SMITHS FALLS ARC — Special events station, CZ3SFR on all HF bands and 2 meters VHF. Send SASE to POB 215 Smiths Falls, ON, Canada K7A 4T1 for QSL — **May 22 - June 7.**

ROCKY MOUNTAIN QSO PARTY — 22-23.

23

PITTSBURG REPEATER ORGANIZATION'S 8TH ANNUAL HAMFEST & PICNIC — Lincoln Center, Pittsburg, KS. Contact KC0ES, 505 Karen Dr., Carl Jct., MO 64834 — 23.

OLD NATCHEZ ARC HAMFEST — Natchez Convention Center. Contact S.W. Gates, N5AXV — 23.

FALL RIVER ARC FLEA MARKET — American Legion Hall, Freetown, MA. Contact Ann Cerro, KA1ONB — 23.

CHIPPEWA ARC 20TH ANNUAL HAMFEST — Garnett North Lake, Garnett, KS. Contact Reid Richardson, 518 West 7th, Garnett, KS 66032 — 23.

ROCKY MOUNTAIN VHF SOCIETY'S ANNUAL SPRING HAMFEST — Boulder National Guard Armory, 4750 North Broadway. Contact Richard Ferguson, KA0DXM — 23

N.K.A.R.C.'S ANNUAL HAM-A-RAMA — Burlington Fairgrounds, off 2-75 Florence exit. Contact Jack R. Thompson, 637 Wolf Road, Covington, KY 41015 — 23.

ILLIANA REPEATER SYSTEM'S ANNUAL DANVILLE AREA HAMFEST — Georgetown Fairgrounds. Contact Wendell Lyons, KA9AYS

3RD ANNUAL MAARC HAMFEST — Ball State University indoor track bldg., Muncie, IN. Contact Terry Evans, WD9HQH — 23.

OHIO RADIO CLUB & OTTAWA COUNTY ARC HAMFEST — Fremont, OH Fairgrounds. Contact John Dickey, W8CDR — 23.

LONG ISLAND MOBILE ARC HAMFAIR — Islip Speedway, Long Island, NY. Contact Sid Wolin, K2LJH or Hank Wener, WB2ALW

28TH ANNUAL BREEZE SHOOTERS HAMFEST — White Swan Amusement Park, PA. Contact Joe Kyler, K3SJD — 23

24

25

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)
AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)
AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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31

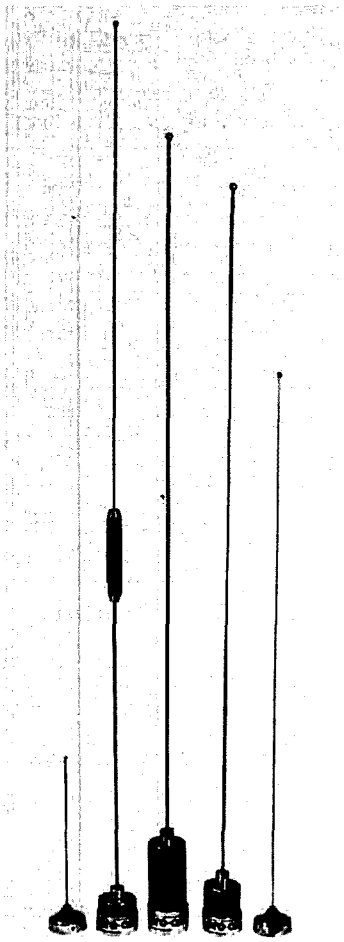
BISHOP ARC will operate KA6AMT from the mule capitol of the world, Bishop, CA, in celebration of the Annual Mule Days. Frequencies: Phone 3905, 7240, 14295, 146.34/94. For QSL send SASE to Bishop ARC, POB 1024, Bishop, CA 93614 — 31.

*See Coming Events

NEW products

Valor's PRO-AM line

Valor Enterprises introduces a new line of PRO-AM (Professional-Amateur) antennas, mounts, and accessories. Valor's PRO-AM line is compatible and interchangeable with the Motorola TAD and TAE type mounts. This system is used extensively in commercial two-way and Amateur applications. Two basic mounts offer installation into a 3/4-inch or 3/8-inch hole; both utilize a 1-1/8 — 18 thread for mating parts. All components are inspected and tested to rigid commercial standards to insure performance in the most demanding environments. Quality materials include stainless steel whips and set screws, nickel-chrome brass parts, heavy gauge weather-proof coils, nickel-silver contacts, and O-ring seals.



PRO-AM antennas. From left, Models PAQ, PUB, PLB, and PAQ.

Four mounts are offered: Model PAS, the basic surface mount that installs in a 3/4-inch hole in roof, fender, or cowl. Includes 17-inches RG-58 with PL-259 connector; Model PAS38, the basic surface mount that installs in 3/8 inch hole in roof, fender, or cowl; Model PAT, a heavy-duty no-hole trunk mount. Black ABS cup, 17 inches RG-58 with PL-259 connector; Model PAM, a low-profile, chrome-plated magnet mount with 12 inches RG-58 with PL-259 connector.

PRO-AM antennas are divided into four types: Model PLB, a 1/4-wave base-loaded low-band antenna. Five models cover 27-54 MHz. 200-watt power-rated, with cutting chart; Model PAQ, 1/4-wave, unity-gain VHF-UHF whips. Twelve models cover 136-866 MHz. Passivated 302 s.s. whips factory tuned, ready to install. Nickel-chrome brass base, 150-watt power-rated; Model PHB, a 5/8-wave, 3 dB-gain VHF antenna. Two models cover 144-174 MHz and 220-225 MHz. 200-watt power-rated, with cutting chart; Model PUB, a collinear 5-dB-gain UHF antenna. Four models cover 440-512 MHz. 200-watt power-rated, with cutting chart.

For more information, contact Valor Enterprises, Inc., 185 West Hamilton Street, West Milton, Ohio 45338; telephone 513-698-4194 or 1-800-543-2197.

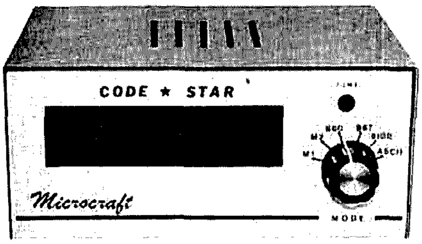
Code*Star

Microcraft announces its new all-mode code reader and code converter, Code*Star. Code*Star is designed for novices, SWLs, and veteran Amateurs. It should also be very useful to people learning or trying to improve their Morse code skills.

Code*Star's microcomputer monitors the incoming signal and converts it to characters on its large, easy-to-read LEDs. It decodes Morse code, Baudot (RTTY) and ASCII code.

Code*Star features two specially optimized Morse code ranges with auto-tracking of speed from 3 to 70 WPM. Special proprietary analog and digital filter methods are employed to substantially reduce errors. An automatic gain control circuit providing up to 16 dB gain is used to help maintain signals under fading conditions. A built-in code practice oscillator is handy for code practice and learning the code.

Code*Star operates on 12 Vdc which makes it ideal for field or mobile applications. An ac adapter is included if you wish to operate it from 120 Vac. As a special option you can use Code*Star to drive a serial or parallel ASCII printer, TV terminal or computer.



Code*Star is available as a complete kit or factory wired and tested. The kit, Model CS-K, sells for $169.95 plus $5.00 shipping and handling. The factory wired version, Model CSF, sells for $249.95 plus $5.00 shipping and handling. The optional ASCII output port kit, Model CS-IK, sells for $69.95 plus $2.50 shipping and handling.

For more information, contact Microcraft Corporation, P.O. Box 513, Thiensville, Wisconsin 53092; telephone 414-241-8144.

NEW products

35-watt, 2-meter amp

The Model 335A-K is an improved version of our reliable Model 335 amplifier kit. The Model 335A-K represents the latest in the state-of-the-art in 2-meter amplifier design. It incorporates new features which make it one of the most useful amplifiers available today.

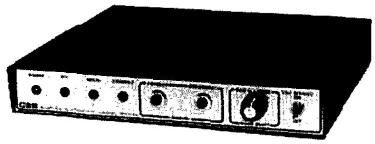
The Model 335A-K is a linear amplifier and can be used on fm, SSB, or CW. The Model 335A-K can be used with all available handhelds (TR2400, TR2500, IC-2AT, Yaesu, Santec, etc.) and low power SSB transmitters to give added range and versatility.

The Model 335A-K can be assembled easily in one evening using the step-by-step instruction manual. The quality parts and rugged construction used throughout the Model 335A-K make it a very reliable amplifier. When you construct the amplifier yourself, not only will you be saving money, but you will also experience the pleasure of constructing some of your own gear.

For more information, contact Communication Concepts, Inc., 2648 N. Aragon Ave., Dayton, Ohio 45420; telephone 513-296-1411.

CES 500SA autopatch

The new CES 500SA simplex autopatch is a high-quality unit that is surprisingly versatile and affordable ($350.00 suggested retail price). It provides positive radio operator control and eliminates telephone VOX circuits with a proprietary noise-gated sampling circuit.



Suggested applications for the Model 500SA include mobile/remote base to telephone line via simplex base; mobile to mobile via phone-interconnected base stations (for greatly extended range); and telephone line to mobile/remote base.

For more information on CES 500SA autopatch and other quality CES products, contact CES, Inc., Post Office Box 507, Winter Park, Florida, or telephone (305) 645-0474.

field-tuneable antenna

Centurion International has introduced a new field-tuneable replacement antenna for hand-held radios in the range of 66-88 MHz.

The new flexible antenna is available with any of the twenty-five different connector configurations in the standard Centurion line. This selection ensures high performance replacements for virtually any radio antenna in this band.

Centurion field-tuneable antennas are protected by a neoprene jacket with flexibility between −55°C and 100°C. The jacket is self-extinguishing when exposed to flame. Approximate length is 10 inches.

For more information, contact Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501-2846; telephone 402-467-4491.

NEW products

XZ-2 audio CW filter

Long known as a manufacturer of quality keys and baluns, Bencher now introduces the XZ-2 audio filter. As mentioned in D.A. Tong's article in the November, 1981, issue of *ham radio*, now that almost all receivers in use by hams feature good basic selectivity, it only makes sense to perform final bandwidth shaping in the receiver's audio section.

Use of the XZ-2 is simple and easy. The filter has four selectivity selections: SSB, 150 Hz, 115 Hz, and 90 Hz. The XZ-2 runs on 12-16 Vdc, which can be supplied by Bencher's 12-volt accessory power supply (#190-10). Audio can be taken from a number of convenient places; Bencher suggests that the phone patch outlet may be the most convenient. For our test, we connected the filter to the external speaker plug and put the filter in line with the speaker. This method provided convenient access to the headphone jack for test purposes. Actual testing took place over several days of casual operating and during CQ's WW CW contest.

When the power is connected, the unit remains on until power is removed. There is no way to completely remove the audio filter from the line, as may be done with several other makes of external filters. This isn't a major problem, however. It means that audio is still slightly amplified by the unit but it is bypassing the filtering stages. To our ear this was a bit of an annoyance, more due to the "newness" of the audio sound rather than a degradation of performance.

To use the filter, Bencher suggests that you tune the receiver with the filter set to SSB. This will allow you to hear a wide range of signals as you tune the CW band. When you hear a station you want, switch in as much

selectivity as is required to eliminate adjacent-channel interference. When you are trying to copy an exceptionally weak signal in the presence of stronger signals, Bencher suggests that you increase the audio gain and decrease the rf gain as much as possible. Reducing the rf gain will limit the AVC control by the stronger signal. While trying to muck out a weak DX signal in the presence of a very strong stateside station, we found that Bencher's suggestions worked very well and we were able to effectively null out the interference created by the adjacent frequency station.

In comparison with the receiver's internal i-f filters and passband tuning, the XZ-2 shows up quite favorably. Used in conjunction with the receiver's built-in filtering, the XZ-2 is even better.

During the CQ WW contest, the XZ-2 was used both independently and with the receiver's filters. Of note is the fact that there are switches to be switched and dials to be turned to use the unit. In the heat of the contest this can hinder speed of operation. It's our operating preference to scan with the filter on wide bandwidth and then narrow down when a station is found. We do not do a lot of contest work, and so this is not much of a problem. But for a dyed-in-the-wool contester, it will be necessary to select, and remain with, one filter position. The filter performed very well during the contest and permitted us to work a number of stations we feel confident would have been missed without the external filter.

One final note. For those who own super-selective receivers, the XZ-2 can be a very valuable addition to the hamshack. As Dr. Tong says, audio filters are the next logical step for improving station performance. We are sure you will be pleased with Bencher's XZ-2 audio filter.

The Bencher XZ-2 filter sells for $69.95, plus $9.95 for 12-volt power supply. For further information, contact Bencher, Inc., 333 West Lake Street, Chicago, Illinois 60606.

the editors

Coming Events
ACTIVITIES
"Places to go..."

ALASKA: The Arctic Amateur Radio Club of Fairbanks will hold a Hamfest, June 5, Kiwanis AG Hall, Tanana Valley Fairgrounds. Doors open 8 AM. $5 sellers' fee. There will be a Left Footed Key for a code contest ending at 5 PM for a pot luck dinner. Also ARRL representatives and Alaska QSL Bureau will be there. For information: Herb Walls, KL7JLF, P.O. Box 1625, Fairbanks, AK 99707.

ARKANSAS: The Northwest Arkansas Amateur Radio Club's 2nd annual Hamfest/Swapmeet, Saturday, May 15, Community Building, Rogers on US Hwy. 71. 8 AM to 4 PM. Commercial exhibitors and flea market tables/space FREE. Doors open 8 AM. Main prizes include a complete Kenwood station, Icom IC2AT hand-held, Diawa Model 720 cross-needle SWR/power meter. Door prizes. Free parking. MARS, DX and Skywarn. Talk-in on 146.16/.76 or 146.52 simplex. Main prize tickets 3/$5.00 or $2.00 each. For information: Mary Webb, KA5HEV, P.O. Box 338, Prairie Grove, AR 72753. (501) 846-2847.

CALIFORNIA: The Fresno Amateur Radio Club's 40th annual Hamfest, May 21, 22 and 23, Hacienda Inn, Clinton and Highway 99, Fresno. Activites include a golf tournament, swap tables, CW contest, MARS meetings, transmitter hunt, cocktail hour, banquet. Talk-in on 146.34/93. Advance registration $20.00. For information/registration: Fresno Amateur Radio Club, Inc., P.O. Box 783, Fresno, CA 93712.

COLORADO: The Rocky Mountain VHF Society's annual spring Hamfest, Sunday, May 23, 9 AM to 3 PM, rain or shine, Boulder National Guard Armory, 4750 North Broadway. Donation $2 per family. Gates open for sellers 8 AM. Bring own tables. Door prizes include synthesized FM transceiver. Extra raffle tickets available. Refreshments available. Talk-in on 146.16/.76 and 146.52. For information: Richard Ferguson, KA0DXM, 1150 Albion Rd., Boulder, CO 80303. (303) 499-2871.

COLORADO: SUPERFEST 4 sponsored by the Northern Colorado Amateur Radio Club, June 5, 8 AM to 4:30 PM, McMillen Building, Larimer County Fairgrounds, Loveland. $3 admission includes swap table. Exhibits, tech talks, code contest with prizes, auction, swapfest, prize drawings including a synthesized 2-meter hand-held. Food service, free parking. Special activities for non-Hams and kids. For information: Gene Bellamy, WD0DRM, 3124 West 6th Street, Greeley, CO.

GEORGIA: The Anderson, Hartwell and Toccoa Amateur Radio Clubs' 4th annual Lake Hartwell Hamfest, May 22 and 23, Lake Hartwell Group Camp, Highway 29. Free admission, free camping (campground opens 6 PM Friday) free flea market space. Bingo, horsehoes, a left-footed CW contest and other activities for the whole family. *Fishing, swimming on site. Main prize drawing 2 PM* Sunday. Talk-in on 146.19/.79, 147.93/.33 and 146.895/.295. For information: Ray Pettit, WB4ZLG, Rt. #1 Dooley Drive, Toccoa, GA 30577.

IDAHO: The Kootenai Amateur Radio Society's Hamfest '82, Saturday, June 12, 8 AM to 4 PM, Kootenai County *Fairgrounds, north of* Coeur D'Alene on old Highway 95. Prizes, flea market, food available. No pre-registration, free tables available. Talk-in on .38/.98. For information: SASE to Avon Anderson, WB7WBZ, N. 1035 Highland Ct., Post Falls, ID 83854.

ILLINOIS: The Illiana Repeater System's 13th annual Danville Area Hamfest, May 23, Georgetown Fairgrounds. Flea market, forums, family entertainment, free parking. Many prizes. Gates open 6 AM. Tickets $2.50 advance, $3.00 gate. Talk-in on 22/82 and 146.52. For information, tickets, tables: Wendell Lyons, KA9AYS, Hamfest Chairman, 930 Polk St., Danville, IL 61832. (217) 431-2124.

INDIANA: The Tristate Amateur Radio Society's annual Hamfest, Sunday, May 16, Vanderburgh County 4H Center, Evansville. Grounds open 6 AM. Admission $2. Outdoor flea market. Indoor tables available. Talk-in on 147.75/.15 and 146.19/.79. For information/table reservations: Hal Wilson, WB9FNN, R.R. #8, Box 427B, Evansville, IN 47711.

INDIANA: The 3rd annual MAARC (Muncie Area Amateur Radio Club) Hamfest, May 23, 8 AM to 3 PM, Ball State University indoor track building, Muncie. Prizes, forums, refreshments, parking. Flea market tables $4.00. Talk-in on 146.13/73, 146.52, 223.10/224.70. Tickets $2.00 advance; $3.00 door. For information: Terry Evans, WD9HQH, 522 S. Brotherton, Muncie, IN 47302. (317) 282-0615.

INDIANA: The Wabash County ARC's 13th annual Hamfest, Sunday, May 16, 5 AM to 4 PM, Wabash County 4-H Fairgrounds, Wabash. Admission $2.50 advance; $3.00 gate. Plenty of food and parking available. Free overnight camping Saturday. Talk-in on 147.63/.03 or 146.52 simplex. For information/tickets SASE to Dave Spangler, N9ADO, 45 Grant St., Wabash, IN 46992.

KANSAS: The Chippewa Amateur Radio Club is having its 20th annual Hamfest, May 23, at Garnett North Lake, Garnett. For information: Reid Richardson, 518 West 7th, Garnett, KS 66032.

KENTUCKY: The N.K.A.R.C.'s annual HAM-A-RAMA, Sunday, May 23, Burlington Fairgrounds, Burlington, off 2-75 Florence exit. Tickets $4.00 each; family ticket $6.00. Each ticket entitles you to major prize drawing at 4 PM. First prize: Kenwood TS-130S or $500.00. Second *prize: Kenwood HC-10 station clock. Special raffle for* Icom 2AT. Door prizes every hour. Indoor vendors, flea market, refreshments. Talk-in on 146.19/79 and 147.86/26. For information — Jack R. Thompson, 637 Wolf Rd., Covington, KY 41015 or call (606) 291-2153.

MAINE: The Portland Amateur Wireless Association and the Southern Maine University Radio Club will hold their annual Flea Market, May 22, Gorham, Maine campus. 8 AM to 4 PM. Admission $1.00. Food available. If raining, will be held inside. Talk-in on 146.73R and 146.52S. For information: John Taylor, N1SD. (207) 773-2651.

MARYLAND: The eighth annual Easton Amateur Radio Society's Hamfest, May 16, rain or shine, 8 AM to 4 PM, Easton Senior High School. Donation $2.00 plus $2.00 for tables or tailgaters. Talk-in on 52 simplex and 146.445/147.045 repeater in Easton. Van Herridge, WB3HGQ, Box J, St. Michaels, MD 21663 or Easton ARS, Box 781, Easton, MD 21601.

MARYLAND: The Maryland FM Association's annual Hamfest, Sunday, May 30, Howard County Fairgrounds, West Friendship. 8 AM to 4 PM. Donation $3.00. Tail-

gating $3.00. Advance tables $6.00 each. Limited quantity at door $10.00 each. Talk-in on 146.16/76 and .52. For information: MFMA Hamfest Committee, PO. Harmans, MD 21077. For Table info/reservations: John Elgin, WA3MNN, 5495 Apt. 2, Harpers Farm Road, Columbia, MD 21044. (301) 596-3741.

MASSACHUSETTS: The South Shore Repeater Association's annual Ham Radio/Electronic/Computer Flea market, Saturday, May 22, Weymouth South High School Cafeteria, 300 Pleasant Street, Weymouth. Doors open for sellers 9 AM; buyers 10 AM. Admission $1 each buyer. Tables $5 advance; $8 as available at door. Refreshments available. All proceeds support the 147.90/30 Weymouth Repeater. For information/advance tables: SSRA, David Newman, P.O. Box 447, Abington, MA 02351.

MASSACHUSETTS: The Hampden County Radio Association's annual Flea Market, Feeding Hills Congregational Church, Rts. 57 and 187, Feeding Hills, May 7, 8 PM. Talk-in on 146.34/94. For information: Larry Langevin, K1GXU, (413) 583-8236.

MASSACHUSETTS: The eighth annual Eastern VHF/UHF Conference, May 14-16, Sheraton Inn and Conference Center, Boxboro. Activities of interest to the serious VHFers. Friday night hospitality room. Saturday night banquet, featuring roast sirloin of beef, $14.00 before May 10. Registration $13.50 to K1LOG, Rick Commo, 3 Pryor Rd., Natick, MA 01760 before May 10. Door registration $20.00.

MICHIGAN: The Central Michigan Amateur Repeater Association's eighth annual Hamfest, June 12, Valley Plaza Complex, off Rt. 10, Midland. 8 AM to 4 PM. Donation $3.00. Children under 12 free. Tables $6.00; trunk sales $2.00. Free parking. Hourly prize drawings. Major prize drawing 2:30. Talk-in on 146.67/07 and 146.52 simplex. Motels, RV hookups, swimming, dining, bowling alley, theaters, picnic area at Hamfest location. For information: Carol Hall, WD8DQG, 4651 Cardinal Dr., Mt. Pleasant, MI 48858. (517) 772-0363.

MICHIGAN: The Chelsea Swap and Shop, Sunday, June 6, Chelsea Fairgrounds, Chelsea. Gates open for sellers 5 AM; public 8 AM to 2 PM. Advance donation $2.00; $2.50 gate. Children and non-ham spouses admitted free. Talk-in on 146.520 simplex and 147.855 Chelsea Repeater. For information: William Altenberndt, 3132 Timberline, Jackson, MI 49201.

MICHIGAN: The Independent Repeater Association's annual Grand Rapids Festival Swap & Shop, Saturday, June 5, 8 AM to 3 PM, Kentwood Field House, south of 60th Street on Kalamazoo Avenue. Admission $3.00. 8 ft. swap tables $7.00; $4.00 half size. Prizes and refreshments. For information or dealer reservations: I.R.A. SWAP, 562 - 92nd St. S.E., Byron Center, MI 49315 or call (616) 455-2926.

MINNESOTA: The North Area Repeater Association's Swapfest and Exposition for radio Amateurs and computer hobbyists, June 5, Minnesota State Fairgrounds, St. Paul. Admission $3. Exhibits, booths, prizes. Free overnight parking for self-contained campers, June 4. Call wide area repeaters 25/85 or 16/76 for directions. For information/reservations: Amateur Fair, P.O. Box 30054, St. Paul, MN 55175.

MISSISSIPPI: Old Natchez Amateur Radio Club's Hamfest, Sunday, May, Natchez Convention Center. Doors open 8 AM. Free admission and swap tables. Food available. Talk-in on 146.31/91. For information: S.W. Gates, N5AXV, P.O. Box 203, Natchez, MS 39120.

MISSOURI & KANSAS: Pittsburg Repeater Organization's 8th annual Hamfest and Picnic, Sunday, May 23, Lincoln Center, Pittsburg, Kansas. Covered dish picnic, chicken and soft drinks supplied. Open 10 AM. Free parking; indoor flea market; door prizes. Grand prizes: FT-208R, Cushcraft Boomer, Ringo Ranger. Grand prize tickets (hams only) $2.00 each to KC0ES, 505 Karen Drive, Carl Junction, MO 64834.

MISSOURI: The Indian Foothills Amateur Radio Club's 7th annual Hamfest, May 16, Saline County Fairgrounds Building, Marshall. Tickets $2.00 each; 3/$5.00 at door or 4/$5.00 advance. No charge for tables but reservations requested. Doors open 8 AM. Coffee and rolls available till 10 AM. An all-you-can-eat lunch at 11:30. First prize drawing 2:30 PM for a KDK 2025 Mark II. Talk-in on .52, .28/.88 and 147.84/.24. For information and tickets: Jim Little, KB0DA, 405 E. Rosehill, Marshall, MO 65340. (816) 886-8583 after 5 PM or K0BVB (816) 886-2837.

NEW JERSEY: The Fort Monmouth ARC and Haverim are sponsoring the Jersey Shore Hamfest and electronic flea market, June 6, 9 AM to 4 PM, Jewish Community Center, 100 Grand Ave., Deal. Admission $3 per person (children under 12 and XYLs free). Refreshments available. Door prizes. Table ($5) and tailgating ($2) spaces may be reserved by SASE and advance payment to: Jersey Shore Hamfest, P.O. Box 2078, Ocean, NJ 07712 by May 25. Talk-in on 147.045 and .6; 146.775/.6; 146.52.

NEW YORK: The 30th annual ROME HAM FAMILY DAY sponsored by the Rome Radio Club, Sunday, June 6,

More Details? CHECK—OFF Page 100

Beck's Grove, Oswego Road, Rome. Activities for Hams and non-Hams; door prizes, presentations of an educational and scientific nature, the area's largest Flea Market. An early brunch will be available as well as a fine buffet dinner. Talk-in on 28/88 and 146.55 simplex. Beck's Grove has overnight parking for campers as well as fly-in capabilities. For information: Rome Radio Club, P.O. Box 721, Rome, NY 13440.

NEW YORK: The Putnam Emergency Amateur Repeater League's *first annual indoor Hamfest, Saturday*, May 8, 9 AM to 4 PM, JFK Elementary School, Foggintown Road, off Route 312, Brewster. General admission 50¢. Exhibitors $2.00. Talk-in on 52 and 146.135/144.535. For information/advance table registration: Frank Konecnik, WB2PTP, RD1-224C, Carmel, NY 10512.

NEW YORK: The Long Island Mobile Amateur Radio Club's Hamfair '82, May 23, Islip Speedway, Long Island. General admission $2.00, exhibitors $5.00 *per* car space. Refreshments available. Door prizes and special prizes drawn all day from 9 AM to 4 PM. Talk-in on 146.85. For information call Sid Wolin, K2LJH (516) 379-2861 or Hank Wener, WB2ALW (516) 484-4322 (evenings).

NORTH CAROLINA: The Durham FM Association's annual Durhamfest, May 15, South Square Mall, U.S. 15-501 south. Admission $3.50 including dealers. Prizes, flea market, free tailgating spaces, overnight parking. Talk-in on 147.825/225. For information: Durhamfest, Box 777, Hillsborough, NC 27278.

OHIO: The Champaign Logan Amateur Radio Club's annual Hamfest and Flea Market, Sunday, June 13, Logan County Fairgrounds, Bellefontaine. Gates open 7 AM EDST. Hourly prize drawings 9 AM to 3 PM. Major prizes of $200, $100 and $50 drawn at 3 PM. Tickets $1.50 advance, $2.00 door. Tables $3.00 advance. Contact M.A. Griswold, W8JXM, P.O. Box 301, Urbana, OH 43078 for information, tickets or tables.

OHIO: The 15th annual Goodyear ARC Hamfest, Sunday, June 13, 10 AM to 5 PM, Goodyear Wingfoot Lake Park, near SR224 and 43 east of Akron. Family admission $2.50 advance, $3.00 gate. Outside flea market $1.00 per space. Inside dealers $5.00 per table. Suggest reservations. Prize drawings throughout day. Grand prizes: First — Kenwood TS-830S; second — Yaesu FT-290R; third — Kenwood TR-2500 and more. Ladies' prizes too. For tickets and information SASE to Don W. Rogers, WA8SXJ, 161 S. Hawkins Avenue, Akron, Ohio 44313. (216) 864-3665.

OHIO: The Athens County ARA annual Hamfest, Sunday, May 16, Athens City Recreation Center, East State St., 8 AM to 4 PM. Free flea market for electronics-related items. Setup 7 AM. Tickets $1 advance; $2 gate. Nearby restaurants and recreation area. Talk-in on 34/94. For information SASE to: ACARA, P.O. Box 72, Athens, Ohio 45701 or telephone Joe Follrod, WB8DOD, (614) 797-4874.

OHIO: The Ohio Radio Club and the Ottawa County Amateur Radio Club and area dealers are sponsoring a Hamfest, May 23, Fremont, Ohio, Fairgrounds. Gates open 8 AM. Dealer setup 7 AM. Advance tickets $2.50, $3.00 door. Talk-in on 31/91 and 52. For table reservations/tickets SASE to: John Dickey, W8CDR, 545 N. Jackson St., Fremont, OH 43420.

OREGON: The Oregon State Ham Convention co-sponsored by the North Coast Repeater Association and the Oregon Tualatin Valley Amateur Radio Club, June 4 - June 6, Seaside Convention Center, Seaside. Friday 12 Noon to 5 PM; Saturday 8 AM to 9:30 PM; Sunday 8 AM to 2 PM. Registration $5.00/single; $7.00/couple; $1.00 children. A special ticket for a drawing of either an Icom 2AT, 3AT, or 4AT plus extra tickets for main prize drawing will be given to those who preregister before March 31. Registrations between April 1 and 30 will receive one extra ticket for main prize drawing. Seminars on receiver design,, construction, contests and more. Talk-in on 146.52 and local repeater 145.45. For information/reservations: Doc McLendon, W7GWC, P.O. Box 920, Seaside, OR 97132.

PENNSYLVANIA: The 11th annual MARC (Milton Amateur Radio Club) Hamfest, June 6, rain or shine, Allenwood Firemen's Fairgrounds, U.S. Rt. 15, 8 AM to 5 PM. Advance registration $2.50; $3.00 gate. XYLs and children free. Flea market, auction, contests. Cash door prizes. Camping and motels nearby. Talk-in on 37/97, 025/625 and 52 simplex. For details: Jerry Williamson, WA3SXQ, 10 Old Farm Lane, Milton, PA 17847. (717) 742-3027.

PENNSYLVANIA: The 28th annual Breeze Shooters Hamfest, May 23, Noon to 5 PM, White Swan Amusement Park, PA, Rt. 60 near Greater Pittsburgh International *Airport*. Registration $2.00 each; 3/$5.00. Free flea market, prizes, family amusement park. Talk-in on 146.28/.88 or 29.0 MHz. Contact Joe Kyler, K3SJD, 4430 Evergreen Road, Pittsburgh, PA 15214. (412) 931-2756.

PENNSYLVANIA: The Warminster Amateur Radio Club's annual Hamfest, Sunday, May 16, Middletown Grange Fairgrounds, Wrightstown (near Philadelphia), 7 AM to 3

PM. Admission $3.00 gate; $2.00 additional for each seller space. Children and spouse free. Pre-registration by May 1, $1.00 off admission. Door prizes every half hour starting 9 AM. Talk-in on 147.690/090 and 146.52 simplex. For information: P.O. Box 113, Warminster, PA 18974 or call Bill Scott, KA3CHB after 6 PM (215) 249-0568.

PLAYBOY RESORT at Great Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07631.

TENNESSEE: The ARRL Delta Division Convention and 16th annual Knoxville Hamfest, May 22 and 23, Bearden High School, 8352 Kingston Pike, Knoxville. Saturday 9 AM to 5 PM; Sunday 10 AM to 4 PM. General Admission: $2 advance; $3 door. All tickets good for grand prizes and door prizes. Exhibitors $8/table both days; $5/table one day. Grand prizes: cash plus many door prizes. Bonus prize Saturday morning drawn on advance tickets. Forums: DX, ARRL, fast scan TV. Women's programs, outdoor flea market, own tables. Saturday banquet, 7:30 PM, Sheraton Executive Park, Knoxville, tickets $15.00. For information, tickets, reservations: Raymond Adams, N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, TN 37921. (615) 688-7771 Days. (615) 687-5410 Nights.

TENNESSEE: The Humboldt ARC's annual Hamfest, Sunday, June 6 at New Location — Bailey Park, N. 22nd Avenue, Humboldt. Tickets $2.00. Prizes, flea market, ladies' and children's activities. For information: Ed Holmes, W4IGW, 501 N. 18th Avenue, Humboldt, TN 38343.

KNOXVILLE TENNESSEE: See World's Fair while attending 1982 Knoxville Hamfest and ARRL Delta Division Convention, Memorial Day Weekend (May 22-23). DX, computer, and technical forums; air-conditioned exhibit area; and large indoor/outdoor flea market make this Tennessee's largest Hamfest. More information? (dealers, tickets, reservations) N4BAQ, 5833 Clinton Hwy., Suite 203, Knoxville, Tenn. 37912.

VIRGINIA: The Ole Virginia Hams ARC of Manassas announces its eighth annual Mid-Atlantic are Quality Hamfest, June 6, Prince William County Fairgrounds. Gates open 8 AM. Tailgating setup 7 AM. Admission $4.00, children under 12 free, tailgaters $3.00 additional per vehicle. Indoor/outdoor exhibits, YL program, refreshments available. Fantastic prizes. Bring your family. Talk-in on 37/97 and 52 simplex. For information: Jim Lascaris, WA2QEJ, 11053 Camfield Ct., Manassas, VA 22110.

WEST VIRGINIA: The Tri-State Amateur Radio Association's 20th annual Huntington Hamfest, Sunday, June 13, Camden Park off route 60 west. 9 AM to 3 PM. Registration $3 per person. Children under 12 free. Flea market $3 per space. Overnight parking for self-contained RVs. Talk-in on 146.04/64 and 146.52/52 W8VA. For information SASE to T.A.R.A., Inc., P.O. Box 4100, Huntington, WV 25729.

WISCONSIN: The 7th annual Swapfest of the Green Bay Mike and Key, Saturday, May 22, Norwood School, corner of 9th and Norwood, Green Bay. 8 AM to 3 PM. Advance tickets $1.50 (by May 1), $2.00 door. Tables $2.00/4 ft. space. Free admission for one for every 2 tables bought. Door prizes. Refreshments available. Talk-in on 146.52 and 147.72-.12. For information: Robert Duescher, 1011 - 13th Avenue, Green Bay, WI 54304.

ONTARIO: The Guelph Amateur Radio Club's 7th annual Central Ontario Flea Market, Saturday, June 5, 8 AM to 4 PM, Regal Hall, 340 Woodlawn Road West, Guelph. Admission $2.00; under 12 free. Vendors $3 additional. Tables available at $5 each. Commercial displays, surplus dealers, computer software/hardware. Refreshment concession. For information: Bob Lacombe, VE3IYE, (519) 843-4618 or Rocco Furlaro, VE3HGZ, (519) 824-1157.

OPERATING EVENTS

"Things to do..."

MAY 12-16: The Holland Amateur Radio Club will operate K8DAA with other participating stations for the Netherlands-American Bicentennial during Tulip Time. Operations on all phone bands and possibly some CW. One contact with K8DAA or two participating stations qualifies for certificate. QSL to HARC, P.O. Box 92, Zeeland, MI 49464.

MAY 15 & 18: The Rockingham County ARC will be operating from the Cape Hatteras Lighthouse on the Outer Banks of North Carolina. This is the tallest brick lighthouse in the country and is designated as a National Historic Landmark. Operating frequencies: 30 Kc up from bottom of general portion of each band, phone and CW.

MAY 16 & 17: W7AQ, the Yakima Amateur Radio Club, will operate a special event station in commemoration of the second anniversary of the eruption of Mt. Saint Helens in Washington State. Join us at 1800 May 16 to 0200 May 17 UTC. Frequencies will be 25 kHz up from bottom of General phone edge; CW up 25 kHz from Novice band edge and at 14.050, all ± QRM and band conditions. A QSL will be available for a SASE to W7AQ, Yakima ARC, P.O. Box 9211, Yakima, WA 98909.

MAY 21-30: The Wiesbaden Amateur Radio Club announces its seventh annual DXpedition to Liechtenstein, callsign DA1WA/HB0. CW, phone and RTTY, all frequencies, 10 to 160 meters including three new WARC bands. CW operations for American stations will be attempted at 3.725 and 21.120 MHz between 1900 and 2100 EST. Stateside OSLs SASE to Stephen Hutchins, Box 4573, APO New York 09109.

MAY 22 & 23: The Clark County Amateur Radio Club, W7AIA, announces the 2nd annual Mount Saint Helens QSO Party. May 22 0001 UTC through 2359 UTC May 23. Frequencies: SSB — 3.805, 7.230, 14.280, 21.360, 28.505. CW — 3.705, 7.105, 21.105, 28.105. VHF — Various Vancouver and Portland area repeaters. To apply for a Mt. Saint Helens Award, send log information or QSL card and $2.00 (or 8 IRCs) to: Award Manager, W7AIA, P.O. Box 1424, Vancouver, WA 98668. All proceeds from the award will go to the Reid Blackburn Scholarship Fund which has been established by the Vancouver newspaper "The Columbian". Reid, KA7AMF, an active member of the club, lost his life during the disastrous eruption of May 1980 while monitoring a U.S.G.S. observation station near the base of Mt. Saint Helens.

MAY 22 TO JUNE 7: The Smiths Falls Amateur Radio Club will be operating a special events station, CZ3SFR, on all HF bands and 2 meters VHF, commemorating the 150th anniversary of the Rideau Canal System linking Ottawa and Kingston. For a special OSL send business SASE to: P.O. Box 215, Smiths Falls, Ontario, Canada K7A 4T1.

MAY 29 & 30: The Neffs Area Amateurs (Belmont County) will operate WB8TOG, the smallest Ham Radio shack in Neffs, Ohio. Work us and let us know if you have a smaller one. May 29 1600Z to May 30 2200Z. Frequencies: Phone 146.46, 28.610, 21.410, 14.340, 7.265, 3.965. CW 28.120, 21.120, 7.120, 3.720. Certificate for QSL card and business SASE to WB8TQG, Floyd, P.O. Box E, Neffs, OH 43940.

MAY 29 & 30: The Orange County ARC will operate WB2TSA to celebrate the Club's tenth anniversary and the Diamond Jubilee of the city of Port Jervis, New York. May 29 1400-2200 UTC and May 30 1400-2000 UTC. Frequencies: 10 kHz up from lower General phone bands. SASE for QSL to OCARC, P.O. Box 434, Cornwall-On-Hudson, New York 12520.

MAY 31: The Bishop Amateur Radio Club will operate KA6AMT from the Mule Capitol of the World, Bishop, California, in recognition of the annual Mule Days celebration. Frequencies: Phone — 3.905, 7.240, 14.295, 146.34/94. For certificate SASE to: Bishop Amateur Radio Club, P.O. Box 1024, Bishop, CA 93514.

JUNE 5: The Pennyroyal Amateur Radio Society's annual Jefferson Davis QSO party, on Saturday, 1500 to 2400 UTC. Suggested frequencies: 3.940, 7.260, 14.310, 21.410 and 28.610 MHz phone and 3.730 MHz CW. An attractive certificate for contacts made that day will be available.

JUNE 5 & 6: Fort Delaware, on Pea Patch Island, Delaware, will be the site of a mini-expedition by Wilmington area hams operating in the General portion of the HF bands during daylight hours only, each operator using his own call and the Fort Delaware identifier. Operators include N3ACU, Doug; N3ARU, Dwight; N3ARV, Ned; KB3HZ, Allen; KB3PD, Rick. This will be the first HF Amateur communications from the fort in the middle of the Delaware River where many Confederate prisoners of war were held during the Civil War. Commemorative QSL cards will be issued for contacts supplying SASEs.

JUNE 12: The Tri-City Amateur Radio Club will operate a special event station from the replica of Stonehenge, near Maryhill, Washington. W7VPA will operate from 1800 to 0100 UTC on or near 3.900, 14.290, 28.690 and 146.52. An attractive certificate will be awarded. Send QSL info and $1.00 to W7VPA, Special Event, P.O. Box 73, Richland, WA 99352.

TO MILITARY COMMUNICATORS: If you have ever served, or are currently serving, with the U.S. Army Signal Corps, either in the military or as a civilian employee, you are invited to join the U.S. Army Signal Corps Association. Communicators from sister services and allies are also welcome to join. Members of the Association receive copies of the *Army Communicator*, the voice of the Signal Corps, as a benefit of membership. Additional information and applications for membership are available by contacting: Signal Corps Association, P.O. Box 7740, Fort Gordon, Georgia 30905.

JUNE 1982 / $2.50

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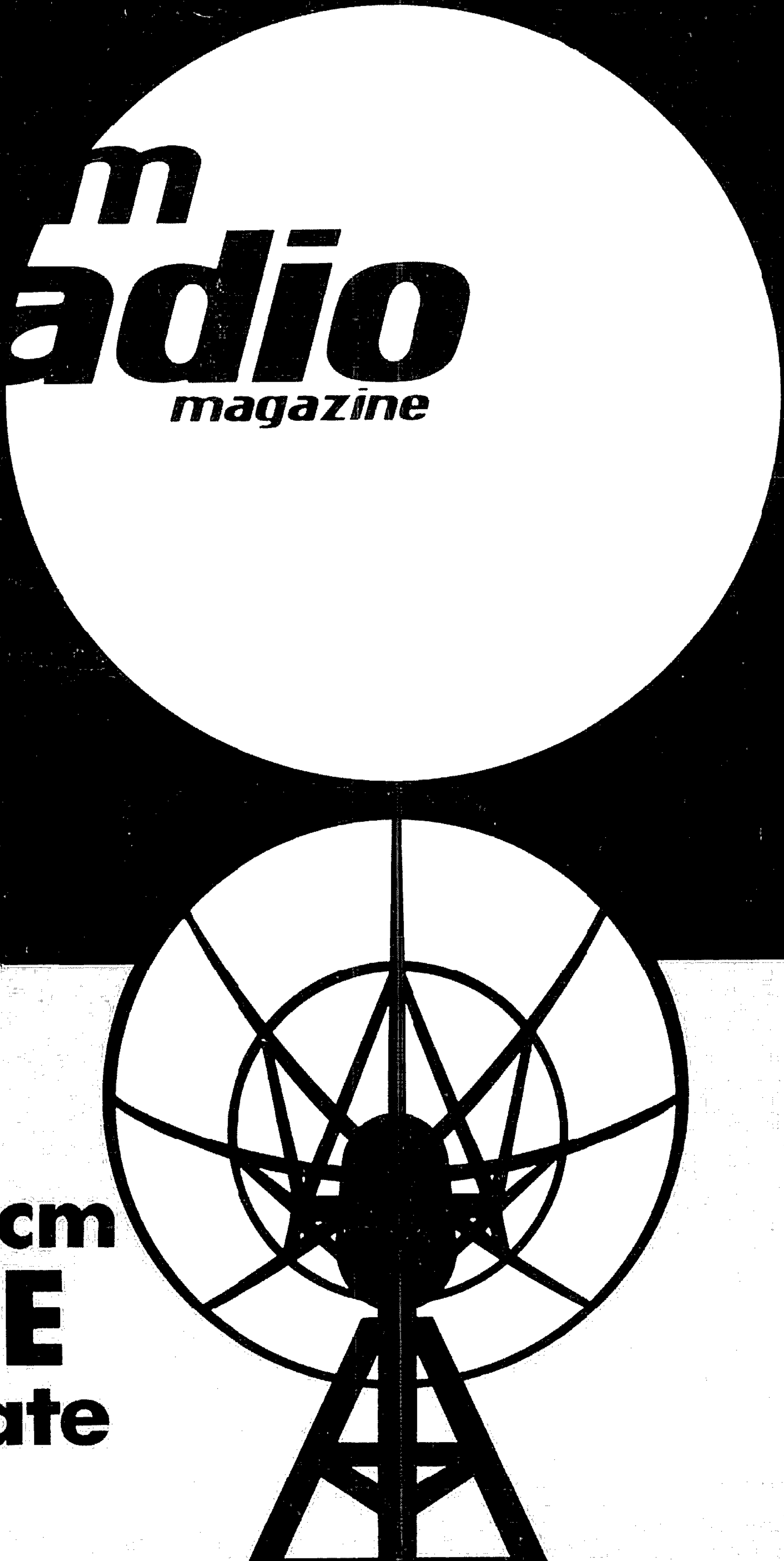

70-cm EME update

ham radio magazine

JUNE 1982

volume 15, number 6

contents

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Observation & Opinion

Monday morning, 0500. It's early and cold. Why am I following this man?

"All right you bums. Get your lazy selves out of bed and let's get rolling!" he yelled. Now I know why. I'm in the Army again.

So began my two weeks' Reserve duty with the 39th Engineer Battalion (Combat) at Fort Devens, Massachusetts. I thought you might be interested in what communications are like in the Army these days. With all the billions of dollars that are being spent on defense you'd expect that state-of-the-art would be the byword. T'aint so!

As a captain, I was assigned to be the Assistant Battalion Communications Electronics officer. It was my job to assist the CE officer and sergeant in training their unit to do their job.

At the battalion level, communications are conducted by two basic means: 30-75 MHz fm radio and wire. Since we were detached from our brigade we also had RTTY, or RATT in military jargon. It was our mission to provide all communications that are necessary to accomplish the battalion's assigned task.

Fm radio is probably the most widely used mode of intra-battalion communications. It's easy to install and operate, and it gives you a tremendous amount of flexibility. But because it is radio, it is easy to locate and interfere with. You can encode signals to keep unauthorized reception to a minimum, but you still are using a transmitter. With radio-location a fairly sophisticated art, fm radio is vulnerable to being compromised (translation: destroyed, you and your radio).

The equipment is of fairly modern design. The basic vehicular radio is the RT-524. The RT-524 is an air-cooled, wideband fm transceiver that covers 30-75 MHz. The RT-524 is a fairly bulky radio, about the size of a small suitcase. It's of hybrid design using tubes and transistors. It's also built to take a fair amount of abuse and keep on cooking. You can switch the output to either low power (about 2 watts) or high power (25 watts). It uses either a PL or noise squelch circuit. Signals can be encrypted, but that is more the exception than the rule here in the U.S. Operating these radios is just like being on 2 meters. Range is basically line-of-sight, usually 5-15 miles depending on terrain and other variables.

Would you want to buy one? If you got one at a super cheap price, sure. Otherwise, the more compact equipment available on the Amateur market today is much more cost-effective and useful for Amateur work. I don't know the exact purchase price of the radio, but it is well over $10,000.

Telephone communications hasn't changed much over the last forty years. Wire is still hard to install and a pain to maintain. Usually it is used when you are going to stay in one place for a while. It's just too hard to lay wire, install phones, and connect a switchboard while you're on the move. It can be done, but it's very taxing to put it in one minute and then rip it out soon after.

The real problem with wire comes after it's been installed. Jeeps and trucks seem to have "wire magnets" that draw them to locations where wire is. Invariably, when wire is in place someone will run a vehicle through it and tear it up. This necessitates walking the line searching for the break and then repairing it. That's not bad on a sunny summer afternoon, but it's a real stinker when you have to tramp through the pucker brush on a rainy, pitch black night.

The basic military telephone, the TA312, has been around for years. It's nothing fancy but it's built like a brick. It runs off two D-cell batteries. To ring, you hand crank a 105-volt pulse down the line. At the terminating point we have an SB-22 switchboard. This equipment is reminiscent of the old pictures of Ma Bell's operators sitting behind racks of jacks using plugs to connect the various circuits together. It's the same way in the Army today. When things get hot and heavy, you will find the operator with arms flying all over the place to keep everyone hooked up. It is a sobering experience for anyone who thinks he can handle a pressure situation. Ma Bell's operators of years gone by deserve a round of applause for having been able to handle it day in and day out.

(Continued on page 47.)

comments

transceiver tuning

Dear HR:

Before the advent of today's transceivers, Amateurs used superhet receivers with a separate beat-frequency oscillator (BFO) whose frequency could be varied above and below the intermediate frequency. In this way, an audio beat note could be obtained by either tuning the BFO above or below the i-f. The pitch of the beat note could be varied to suit one's taste. Later designs included crystal or other filters to eliminate one of the potential beat notes on one side caused by a near-frequency interfering signal. Receivers using this system were known as "single-signal" superhets.

Present-day transceivers use the single-signal filtering system to a degree of refinement wherein only one beat-frequency sideband will be used in the receiver. For CW, beat notes are provided at a single, not-readily adjustable frequency: 800 Hz, for example, in my Kenwood TS-180S. (I would like a panel control to adjust this frequency in accordance with my day-to-day or even hour-to-hour taste. Most, if not all transceivers, do not supply such a capability.)

Back to the modern transceiver — in this case the Kenwood TS-180S. The instructions state: "Tune the receiver to the desired incoming signal to obtain an 800-Hz beat note. The transmit frequency is now automatically zeroed to the received signal." This confused me (and others) at first, since upon pressing the key, the digital readout increased by 800 Hz. But on thinking about it, I realized this is normal and correct.

Fig. 1 helps to explain the operation. The receiver is tuned to an incoming signal to obtain maximum response at 800 Hz (or other frequency, depending on the beat frequency selected by your transceiver). The receiver will be actually tuned (as indicated by the dial and digital readout) to a frequency 800 Hz lower than that of the incoming signal. There is no loss of received signal strength, since the signal is still within the i-f passband.

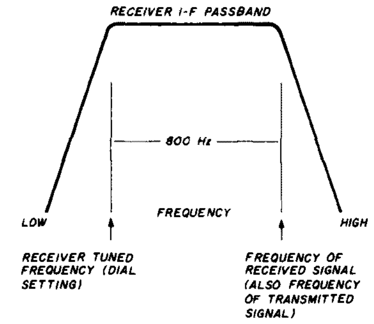


fig. 1. Relationship of dial setting and received (or transmitted) frequency in modern transceivers.

Keying the transceiver provides 800-Hz offset in the direction of higher frequency, thus transmitting a signal that is at the same frequency as the received signal. This makes it easy for the other operator to receive your signal. He can, of course, vary his receive beat frequency (as you can) by using the Receiver Incremental Tuning (RIT) control, which does not affect transmit frequency. This helps in avoiding chasing each other around an initial frequency. If at least one of the two operators uses his RIT, then, once settled, there will be no further need to adjust frequency by either one.

I'm not sure whether there is industry agreement on which sideband to select for use in the CW mode, but it wouldn't make any difference. A technique for using the sideband other than that used in the TS-180S would be to tune the receiver to a higher frequency (by 800 Hz or so) than the received frequency.

Finally, if I had my druthers, this is what I would like:

1. CW pitch variable with a front panel control. It should not vary either receive or transmit frequency.
2. The receive and transmit frequency should be at the *same place on the dial*, as indicated by the analog and digital readouts.

G.W. Legel, N6TO
Fullerton, California

CW nets

Dear HR:

Because of my interest in public service and CW operation, I have compiled a list of groups that operate on Novice/Technician high frequencies (80 through 10 meters) at slower speeds and welcome newcomers. This list is referenced to time (UTC) and contains information involving day(s) of session(s), frequency (kHz), net name and abbreviation, net manager, area of coverage, and purpose of operation.

The list is available from me for an SASE.

Mike Adams, N4EVS
Route 4, Box 764
Panama City, Florida 32405

cancer warning

Dear HR:

In your January, 1982, issue, on page 82, there is an article by Robert Wheaton, W5XW, on metal cleaning. He lists the active ingredient as thiourea.

Well, thiourea is listed in the publication *Cancer Causing Chemicals* by N. Irving Sax (Van Nostrand Reinhold Co., New York, 1981). I think you should warn your readers about its use.

Normal Wells, K6YPD
Inglewood, California

presstop

THE PHASE III-B LAUNCH has been delayed for at least two months. A problem with the MARECS-A, put into orbit by the European Space Agency on board Arianne LO-4 a few months ago, is the cause of the delay. A plasma ring has developed around the satellite, causing a corona discharge and seriously impairing the satellite's operation. The E.S.A. ordered the freeze on future Arianne launches to give its scientists time to investigate the cause of the problem and find a solution.

It Is Believed that an out-gassing effect from the MARECS could be the cause but scientists want to be sure. The launch date for Phase III-B may slip even further, as it's expected that many of the E.S.A.'s other customers will be vying for preferred launch dates on a revised schedule now being prepared by that agency. Phase III-B was scheduled to be placed into orbit on board Arianne LO-6 in late July, but it now must wait for a new launch commitment.

JAPAN WANTS TO ESTABLISH reciprocal operating privileges. Their Ministry of Post and Telecommunications has sent letters to twelve nations requesting information it will then use to formulate plans for operating agreements. The countries approached are Australia, Brazil, Canada, Finland, Germany, Great Britain, Ireland, New Zealand, Norway, Sweden, Switzerland, and the United States.

THE ITU REGION I MEETING was a total success, according to ARRL General Manager Dave Sumner, K1ZZ. While complete details of the April 1st meeting which took place in Manila are not yet available, Sumner says that many important issues were agreed upon. Region 2 was well represented by Victor Clark, W4KFC; Dick Baldwin, W1RU; Carl Smith, WØBWJ; and Noel Eaton, VE3CJ.

THE NEW GENERAL RADIOTELEPHONE operator's license, which replaced the old 1st and 2nd Class licenses, now has a new test as well. The Commission has combined the necessary test elements into one examination to eliminate the need for three separate tests. To obtain the GRT license, an applicant must pass an exam of the same difficulty as that of the old 2nd Class test.

A CODE-FREE AMATEUR LICENSE is still a distinct possibility some time in the near future. The Commissioners were scheduled to take up the question of creating such a new license class at their meeting last week, but action on it was deferred to some later date. No reason was given for the delay.

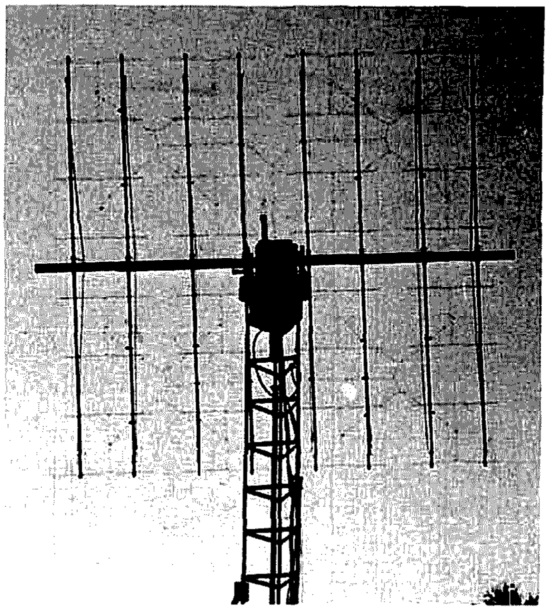
THE RETURN TIME PERIOD for Novice exams has been extended to sixty days from the current thirty by FCC action. This means an applicant will have sixty days in which to take the exam and return it to the Commission for grading, and it's especially helpful to clubs and schools who order the examinations in bulk for use as a final exam in Amateur Radio training courses.

THE FCC HAS TAKEN ACTION against a licensee in the Grizzly Peak jamming case. Donald E. Gilbeau, N6OZ, has had his station license revoked and his Extra Class operating privileges suspended for what the Commission alleged to be his jamming of the Grizzly Peak repeater in California's northern Central Valley. N6OZ was one of a number of hams charged by the FCC with malicious interference and jamming of the system over one and a half years ago. In May, 1980, N6OZ was monitored by an FCC engineer of the San Francisco field office transmitting "random words, Morse code, and unintelligible sounds" on 146.22 MHz, the input frequency of the repeater. At his show cause hearing last year, N6OZ claimed that all but one of the alleged transmissions were accidental. The administrative law judge who heard Gilbeau's case found otherwise; he agreed with the Private Radio Bureau's contention that Gilbeau's claim was false, and that "any leniency that Gilbeau's long, previously unblemished record as an Amateur might warrant was outweighed by the attempt at deception." The findings in the N6OZ case are the first of many expected in the Grizzly Peak matter.

THE PERSONAL COMMUNICATIONS FOUNDATION seeks data on CATV RFI for their legal library. As they've done in the past with tower and antenna ordinances, they intend to collect information on this subject for Amateurs involved in cable TV RFI problems. Information should be sent to The Personal Communications Foundation; c/o Astor & Merdler, Attorneys; 9036 Reseda Boulevard; Northridge, California 91324; attention: Joseph Merdler, N6AHU.

TWO SECTIONS OF THE RULES have been deleted. Part 97.74, which required a licensee to provide for measurement of his transmitter carrier frequency, and Part 97.71, which required an Amateur to use an adequately filtered DC supply on any transmitter operating below 144 MHz, were both deemed antiquated by the Commission. They feel that Amateurs realize both are simply good operating procedures, and so deleted the language in keeping with the FCC's policy of simplifying regulatory procedures in all services it supervises.

An overview of what's needed for 432-MHz moonbounce operation



This photograph was taken by W1OG while the author was in contact with YV5ZZ on 70-cm EME in July of 1977 at 2300 UTC. Note moon in lower right quadrant. Antenna is a 128-element extended, expanded collinear array (reference 12).

requirements and recommendations for 70-cm EME

Seventy-centimeter EME has really matured since my report in 1973.[1] EME contacts are now routine, with many stations having worked all continents and over twenty-five DXCC countries. By 1980 over 150 different stations had reported two-way contacts, and two-way SSB contacts were quite common. Three stations now have a WAS on 70 cm and others are not far behind. This would have been impossible on 70 cm without EME.

The basic requirements outlined in my original report still stand. However, the state of the art has advanced a great deal since then, and I think it's about time to update the recommended equipment list, consolidate most of the material in one place, and provide a list of selected references on the subject.

While all these improvements were becoming available, many 70-cm EMEers have tried to outdo each other by building larger and more efficient antenna systems than are required to hear their own echoes. As a result, newcomers now can make contacts even if their station is only marginal (not quite capable of hearing one's own echoes). The block diagram in **fig. 1** gives the overall system picture, and you can refer to it as I describe each element in a typical 70-cm EME system.

minimum requirements for 70-cm EME

The ideal plan is to build a station that gives you the capability to hear your own echoes. This will allow you to have a built-in test facility, since you will

By Joe Reisert, W1JR, 17 Mansfield Drive, Chelmsford, Massachusetts 01824

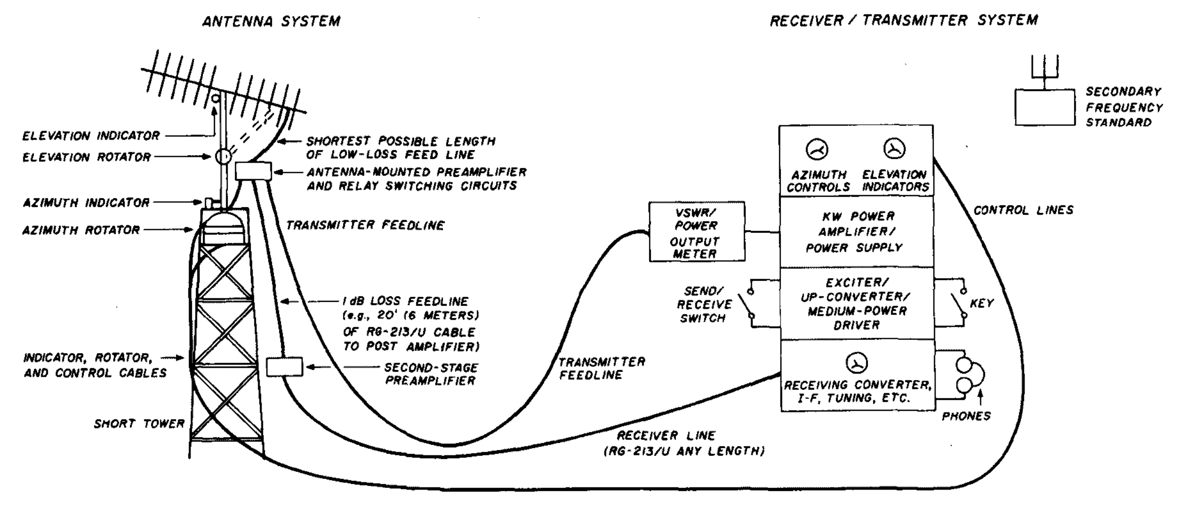


fig. 1. A typical 70-cm EME installation.

be able to evaluate system changes and improvements by echo testing. Based on a 0-dB signal-to-noise ratio and no Faraday rotation (a change in polarization that occurs when a VHF/UHF signal passes through the ionosphere), the following requirements apply:

1. Path loss, 262 ± 1 dB.*

2. Minimum antenna gain, 25 dBi (gain over an isotropic radiator).†

3. Maximum receiver noise figure, 2 dB (referenced to the antenna feed point).

4. Minimum transmit power, 500 watts output (at the antenna feed point).

5. Receiver bandwidth, 500 Hz.

antennas

The most important piece of equipment in an EME station is the antenna system. This is true because the antenna is present in both the received and transmitted paths. Hence a 1-dB antenna gain increase will yield a 2-dB system improvement. It is also desirable that the antenna radiation pattern be as clean as possible. Rear and side grating lobes (lobes that result when you stack identical antennas) should be at least 13 to 15 dB down from the main lobe, and 15 to 20 dB is preferred. A good, clean pattern means that all transmitted power is aimed at the moon and that extraneous noise sources are not picked up by the receiver.

Parabolic antennas. These antennas, with dish diameters of 18 to 40 feet (5.5 to 12 meters), the minimum recommended for 25 dBi gain, are very popular on 70 cm EME. They have a f/d (focal length to diameter) ratio of 0.45 to 0.55. If properly designed, they provide high gain and they are very quiet on receive. They have the extra advantages that they are easily adapted to adjustable polarization feeds (to offset Faraday rotation) and they are usually usable on other frequency bands (for example, 23 cm) by simply changing the feed system. Some stressed dishes[2,3] are in use, but trussed rib designs[4,5] are recommended for improved performance and durability.

Properly feeding a parabolic dish is the secret to success. The most popular and efficient feed for dishes having f/d ratios of 0.45 to 0.55 is the EIA (Electronics Industries Association) dual-dipole reference standard.[4,6] K3BPP has designed a similar feed system,[7] which provides both horizontal and vertical polarization for instantaneous polarity change or circular polarization. It is important to remember that the overall efficiency of a parabolic dish is typically 50 to 55 percent at best.

Yagis. Yagi arrays are also very popular, since such an array is usually smaller than a dish of equivalent gain and is less of a problem to maintain in severe weather areas. The WØEYE Yagi[8] is very popular among homebrewers. It is important that this and

*The one-way path loss to the moon is approximately 197 dB at 70 cm. The moon's surface has a gain of 132 dB as a passive reflector at 70 cm. Hence the round-trip loss is $197 + 197 - 132 = 262$ dB.

†An isotropic antenna is an imaginary mathematical model that radiates power equally in every direction. Generally speaking, a dipole has a gain of 2.14 dB over an isotropic antenna.

other designs be duplicated exactly as shown by the designer to achieve optimum performance. Several persons have taken the liberty of adding extra elements or making other changes to this or other designs only to find out that gain dropped. *Changes should never be made unless adequate testing facilities are available to verify the performance after modification.* Eight of these Yagis properly built will be capable of marginal EME, but sixteen will be quite acceptable. The best stacking distance seems to be about 4-1/2 feet (1.37 meters) in the *E*-plane (horizontal) and 4 feet (1.22 meters) in the *H*-plane (vertical). Other Yagi designs are also available.[9] The quagi, a Yagi with a quad reflector and driven element,[10] is also in use and is inexpensive to build but has 1-dB less gain than claimed. Spacings similar to the WØEYE Yagi are recommended for a quagi array and a minimum array of sixteen quagis is suggested to those interested.

Excellent commercial antennas are now available such as the F9FT twenty-one-element array on a 15-foot (4.5-meter) boom and the K2RIW nineteen-element on a 13-foot (4-meter) boom. Eight of these antennas in an array (four wide and two high or vice versa) spaced at 5 feet (1.5 meters) in the *E*-plane and 4-1/2 feet (1.4 meters) in the *H*-plane will deliver very acceptable performance, while sixteen will put you in the big league. The K2RIW Yagi has recently gone out of production, but a similar design, the TAMA SST-0719, is being imported from Japan and sold by Lunar Electronics.* The K2RIW nineteen-element Yagi has been widely duplicated by home-brewers.†

Other configurations of antennas are also usable.[11] The extended expanded collinear array[12] with 128 elements has been used by several 70-cm EMEers. Additional improvements to this design are available from the author (see note 1 in reference section). It is low in cost, easy to build, and relatively broadbanded, (meaning fewer mechanical tolerance problems). It can be easily set up for polarity rotation. Another choice would be an array of from sixteen to thirty-six, 1-2.2 wavelength long Yagis.[9]

Some closing remarks about antenna systems may be in order (also refer to the system checkout section of this article). High antenna gain implies narrow beamwidths. A 25-dBi-gain antenna will have a half-power beamwidth that will be no greater than 12 degrees (and probably much less) in at least one of the planes. Higher gain antennas will be commensurately narrower. Since gain is so important, it is desirable to keep the antenna aimed within its 1-dB beamwidth, which would be less than 6 degrees. With moderate gain (25-dBi) antennas it is necessary to re-aim your antenna only every 10 to 15 minutes. Beginners can easily do this by using setting circles and going outside to re-aim the antenna when required. It is desirable, however, to have a good rotator and readout for routine and continued operation.

A converted prop-pitch motor[13] with a 1.0-degree readout indicator[14] is satisfactory. Several rotator and readout systems have been published.[15] The sun and the star Polaris (for Northern Hemisphere stations) can be used for rough calibration. A carpenter's level and protractor can be very useful for accurate elevation settings.

receivers

Most 70-cm EMEers prefer to use one or more antenna-mounted preamplifiers with very low noise figure ahead of a crystal-controlled down converter located in the radio room. This is fed into a suitable high-frequency receiver. A desirable converter for EME work should have a noise figure of no greater than 3 dB with at least 15 to 20 dB of image rejection. It is now possible to build a high-quality down converter[16] with adequate filtering, a double-balanced mixer, and a clean local oscillator (a 28.1-MHz i-f is recommended using a 100.975-MHz crystal to prevent spurious beats when calibrating and to give adequate tuning range if the crystal is slightly off frequency).

The most commonly used commercial down converter is the Microwave Modules MMC-432/28S (or the MMT-432/28S transverter described in the transmitter section of this article), also usable on OSCAR. The earlier Microwave Modules converters/transverters (before the S models) had insufficient image rejection or a higher-than-desired noise figure.

Preamplifiers. Low-noise preamplifiers have come a long way in the last few years. The NEC V645 bipolar transistor has been in wide use and easily can yield a 1.0 dB noise figure. If operated in an area with high levels of rf (such as near TV or fm stations) it is susceptible to intermodulation distortion. A low-loss input filter[17] or a built-in filter[18] will help keep unwanted signals out. An acceptable commercial bipolar preamplifier using the V645 is the Lunar Electronics model PAE 432-5.

Recently, GaAs FETs have become readily affordable and available. The NEC V244, Mitsubishi MGF 1400, and the Dexel D-432 are the most popular GaAs FETs, and all are capable of noise figures in the 0.5-1.0 dB region with 18-25 dB gain. Because of the

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*Lunar Electronics, 2775 Kurts St., Suite 11, San Diego, California 92110.

†Suitable insulators are manufactured by Amcraft, c/o Bob Johnson, K9KFR, Rt. 4, Road 600 N, Columbia City, Indiana 46725.

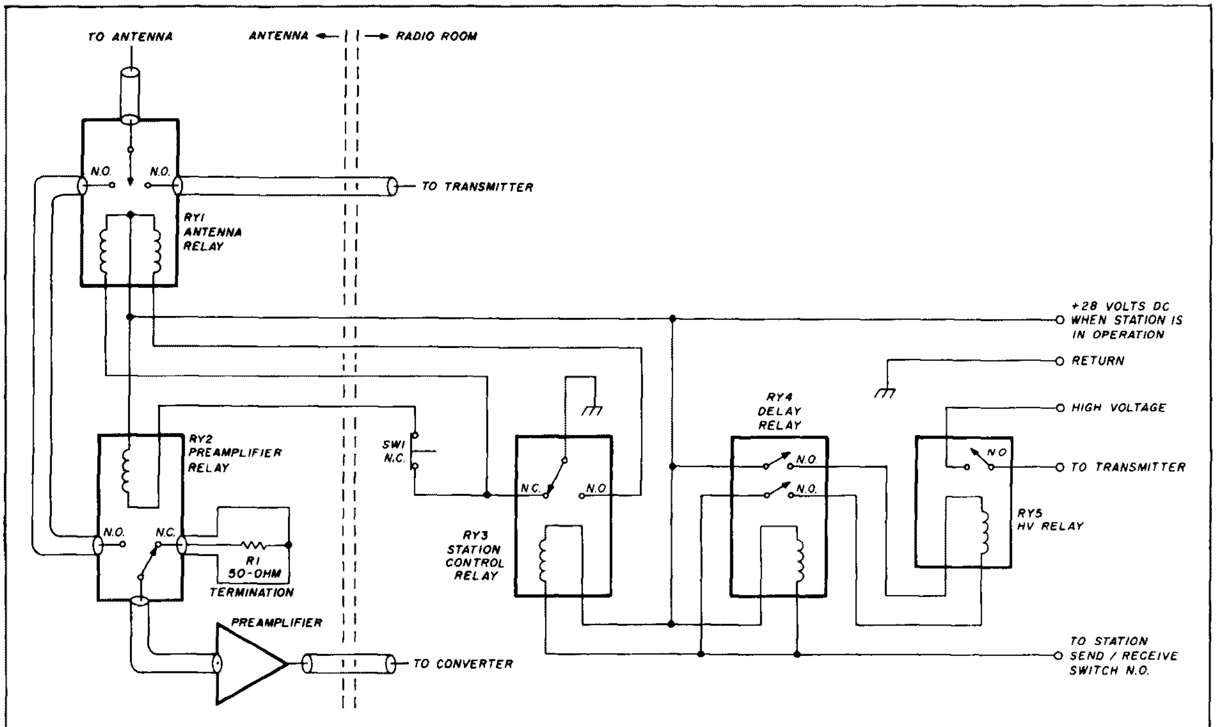

fig. 2. EME antenna relay and switching scheme (from reference 21). Resistor R1 is used to terminate the preamplifier when the latter is on standby, thus providing additional isolation from the transmitter.

higher input impedances of these devices, it is easier to design a preamplifier with a built-in input filter as part of the input-matching network. One of the most popular circuits was developed by W6PO and makes use of a D-432 with a microstrip input circuit and a bifilar-wound transformer on the output.[19] This preamplifier is now available from Lunar Electronics (Model PAG-432).

A few important things should be considered before you spend your time and money on your state-of-the-art preamplifier. I'd recommend that you first build an inexpensive preamplifier with a moderate (1.75-dB) noise figure using a device such as the Motorola MRF 901,[20] which costs less than $3.00. Use this preamplifier, antenna mounted, as your first stage until you have completely debugged your relay switching system (more on this shortly) and have successfully transmitted with full power into your EME antenna. If you do have an accident (as many others have), it will not require a very costly repair. This preamplifier is capable of receiving EME signals as is. After you are confident you have no switching or isolation problems, then you can use this preamplifier for your second stage and put your super-low-noise preamplifier ahead of it with a 1-dB-loss feedline in between (see **fig. 1**). It is also a good idea to keep a spare preamplifier handy just in case it's needed!

Isolation. The low-noise devices we have been discussing are really a breakthrough in the state of the art, and they are far less complex and costly than the parametric amplifiers used during the 1960s. They are very susceptible to burnout from transients or high (100 milliwatt or more) input power, however, and hence must be carefully protected. Never use a power supply for your preamplifier that is also used to control relays, since transients may be induced from the relay coils into the preamplifier and destroy the device. It is preferable not to exceed 1 milliwatt into the preamplifier. With an rf power level of 500 watts, this suggests that the isolation of the antenna transfer relay should be 57 to 60 dB as a minimum. The typical Dow-Key relay, even with type-N, connectors has only 30 dB receiver-to-transmitter isolation (at 432 MHz), while the Transco Y-type relay is generally around 60 dB. This is too marginal. Futhermore, preamplifiers of this type do not like to operate with a shorted or open input during transmit.

A double relay scheme (**fig. 2**) is therefore highly recommended. The preamplifier has its own separate relay (a low-power type is usually adequate) that terminates the preamplifier into a 50-ohm load during transmit and provides additional isolation from the transmitter.[21] To obtain most of the additional isolation from the second relay, the transmission line between relays RY1 and RY2 should be 0.10-0.25

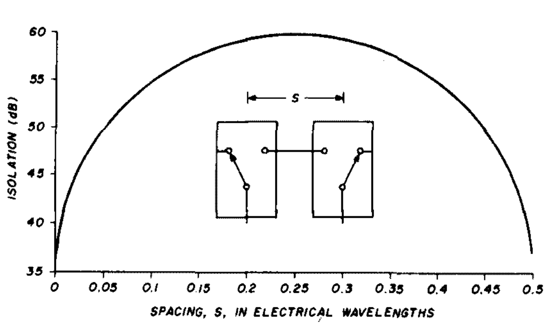

fig. 3. Approximate isolation of two relays (each 30 dB isolation) spaced by the transmission line.

wavelength (see **fig. 3**). Two relays butted closely together will exhibit only 6 dB more isolation than the best one alone.

Last but not least, the preamplifier should always be mounted as close to the antenna as possible, preferably at the central feed point. This is necessary because feedline loss does not add dB for dB to the noise figure with the cold sky (typically 20 to 70 degrees Kelvin) experienced on 70 cm. A feedline loss of 0.25 dB *can* degrade system receive sensitivity by up to 1.0 dB!

I-f system. The foregoing is all academic unless your i-f system is very stable (25-50 Hz short-term stability) and has slow tuning capability. Also it may be desirable to have an i-f bandwidth of 200-500 Hz for CW work with very weak signals. Special receivers are not required, as most modern receivers meet these requirements. Some operators can use wider i-f bandwidths, while others even add a narrower bandwidth filter (passive or active type) in the audio system. CW operators long ago realized that they can copy weak signals with wider bandwidths even in heavy QRM, because the human ear *and* brain can be trained to narrow hearing bandwidth to perhaps 20-50 Hz and vary in frequency response at will.[22]

Successful contacts also require good frequency accuracy (± 1 kHz is recommended) both on the transmitter and receiver. A very stable 3 or 4 MHz accurate secondary frequency standard (calibrated to WWV) is highly recommended. On 70-cm EME, a received signal can be as much as ± 1.5 kHz different from the original transmitted signal frequency due to Doppler shift (the moon is usually approaching or leaving the receiving station; hence the signal frequency varies in a manner similar to that of a moving train whistle). Echoes will be higher in frequency when the moon is east of your local longitude and lower in frequency after the moon transits your longitude. Stations should always set their transmitter to the true scheduled frequency and offset their receiver as required by Doppler shift.

transmitters

Tripling from 144 and 432 MHz is a simple way to build an exciter, but stability is usually not good enough for EME operation. It is now common practice to heterodyne a 28- or 50-MHz exciter to 432 MHz. Not only does this usually improve stability, but it also allows the use of SSB. The most common type of up converter has an output of 5-10 watts. The Microwave Modules MMT-432-28S is one of the most popular commercial types and is all solid state. It also has the desirable feature of a built-in receiving down converter.

Most present-day 70-cm power amplifiers require 25-40 watts of drive power. Many operators use a solid-state power amplifier to increase the transverter-exciter output. Several commercial units are available and most are acceptable; but one that can also be operated as a linear is desirable, since it will be easier to adjust drive level and can also be used for SSB operation. A simple amplifier with a 2C39 equivalent tube is also usable and sometimes available at a reasonable cost. One example is to use the cavity from a Motorola T-44 transmitter strip.[23]

The most popular 70-cm power amplifier is the parallel-tube stripline kilowatt using 4CX250 tubes designed by K2RIW[24] with special modifications.[25] W2GN has made additional improvements to this amplifier and stocks all the required parts necessary for construction. He will even sell a kit or an assembled and tested unit complete with power supply.* In addition, some EMEers have slightly modified the plate line on the K2RIW kilowatt and substituted type 8930 tubes for greater output and better thermal stability. Some of the keys to success are a low-impedance bias supply (1000 ohms or less) for the input grid, good low-loss sockets with built-in screen-grid bypasses and shielding (for example, the Eimac SK-620 or SK-630), a shunt-type screen regulator (VR tube) with 20,000 ohms or less resistance *from each tube screen grid to ground*, and adequate air circulation to prevent thermal drift.

The W1QWJ push-pull amplifier using 4CX250Bs[26] is also capable of high-output power, although some claim it is more difficult to get operational initially. Some recommended improvements are available.[27] ZE5JJ has further increased the output power by shortening the output loop by 1 inch (4.25 versus 5.25 inches), and using separate screen meters to monitor balance.

Some RCA type 7650 or 7651s are in use in a single-tube microstrip configuration. The larger RCA

*Fred Merry, W2GN, ARCOS, Box 546, East Greenbush, New York 12061.

table 1. Transmission-line characteristics of commonly used coaxial cable (note 1).

cable type	loss (dB) (note 3)	power handling capability (watts)	velocity of propagation factor
RG-58C/U	11.5	75	0.659
0.141 semirigid, PTFE dielectric	7.5	1000	0.75
RG-8/U (note 2)	4.75	350	0.659
RG-213/U	4.75	350	0.659
Belden 8214	4.0	350	0.78
RG-17/U	2.0	1000	0.659
1/2 inch (1.3 cm) Alumifoam, RG-231/331/U	2.0	1000	0.80
1/2 inch (1.3 cm) Heliax,* RG-366/U foam dielectric	2.0	1000	0.79
1/2 inch (1.3 cm) Heliax,* air dielectric	1.8	1000	0.914
7/8 inch (2 cm) Alumifoam, RG-332/333/U	1.4	2000	0.80
75-ohm CATV 3/4 inch (1.9 cm) polyethylene dielectric	1.1	1500	0.80
7/8 inch (2 cm) Heliax,* RG-323/U foam dielectric	1.1	2000	0.79
7/8 inch (2 cm) Heliax,* RG-318/U air dielectric	0.85	2500	0.916
75-ohm CATV 1 inch (2.5 cm) polyethylene dielectric	0.85	2000	0.80
1 5/8 inch (4 cm) Heliax,* polyethylene dielectric	0.85	5000	0.79
1 5/8 inch (4 cm) Heliax,* RG-319A/U air dielectric	0.45	6000	0.921

Note 1. These are approximate figures but good for comparison. All the data presented is for 70 cm (432 MHz).

Note 2. The RG-8/U coax produced in recent years may have higher losses than quoted. See text for further information.

Note 3. *All losses are nominal for 100 feet* (30.5 meters). Air dielectric Heliax* loss figures apply only if the cable is moisture free and is pressurized with dry air or nitrogen.

*Registered trademark of the Andrew Corporation.

7213 or 7214s have been used in some cavity amplifier designs. Others have used the Eimac 8938.[28]

feedlines

No article on 70-cm EME would be complete without a few words on recommended feedlines. *All* antenna feedline losses must be kept to a bare minimum. Yagi arrays are usually fed with the shortest possible length of RG-213/U (the current military version of RG-8/U) or Belden 8214 foam dielectric coax. The latter uses a slightly larger inner conductor (a UG-21B connector is recommended). Also the lower dielectric constant (foam versus polyethelene) is more prone to phasing variations. Some operators are now switching back to open-wire line, which is virtually lossless except during wet weather. RG-8/U coax should be avoided because it is no longer made to military specifications, and the shield coverage has been reduced. In addition, a plasticizer in the jacket will contaminate the dielectric and losses will increase with time. Larger and lower-loss coax is recommended, especially after the first power divider in a Yagi array. For comparison I have included various feedlines and their characteristics in table 1.

If the preamplifier is mounted at the antenna feed, its output can go to the next stage through a 1-dB-loss coax cable (for example, 20 feet, or 6 meters, of RG-213/U) to both stabilize the preamplifier and to allow it to be mounted in a more convenient place outside the antenna feed system. The losses ahead of the first preamplifier must be kept low (and should never exceed 0.5 dB). The transmitter feedline loss is on a dB-for-dB basis and should be low enough (typically 1 to 1.5 dB) to obtain the recommended 500 watts output at the antenna. One-half inch (1.3 cm) or larger hardline is definitely recommended, and air dielectric Heliax™ (if you can afford it) is preferred

but must be pressurized with dry air or nitrogen if its low-loss properties are to be maintained. Recently there has been a surplus of large (3/4-1 inch or 1.9-2.5 cm) 75-ohm foam dielectric CATV feedline. This is definitely usable if suitable impedance transformers[29] and connectors are obtainable.

scheduling

Seventy-cm EME schedules are usually conducted between 432 and 432.05 MHz and are thirty minutes in duration with most westerly station (with respect to the international date line) transmitting the first 2-1/2 minutes of each five-minute period. *The last thirty seconds of each transmitting period is reserved exclusively for signal reports. Do not transmit during this time if you are not sending a signal report.* The reporting system is quite similar to meteor-scatter procedures. The letters T-M-O are used, with T meaning detectable signal or letters, M meaning the call signs have been positively identified, and O meaning signals are Q5 copy. For a valid contact, both stations must send and receive an M or O plus a receipt acknowledgment (an R or roger). Schedules are coordinated through the 70-cm EME net, which meets from 1600 to 1700 UTC every Saturday and Sunday on 14.345 MHz, or through the various schedule coordinators, who are published in the 70-cm EME newsletter.* Most activity takes place on the weekend when the moon is nearest perigee (closest to the earth) and at positive delination (north of the earth's equator), excepting the new moon. Additional information on scheduling and locating the moon has also been published.[30,31]

system checkout

Now that you are all ready, you're probably asking yourself, "How do I know it's all working?" If you have followed all the above and have a station that meets the minimum recommended requirements, you may try echo testing. The round trip time for the EME path is just over 2.5 seconds, so letters or long dahs can be sent and listened for (don't forget to compensate for Doppler shift on your receiver). Hearing echoes is great, but don't be discouraged if you do not hear signals right off. Be patient! The Faraday rotation may not be right. It may take hours for the correct polarization to occur and could be longer during the nighttime when ionization changes at a slow rate. Better yet, set up a schedule and see if you or the other station hear each other.

Other tests can and should be conducted to verify system performance. First, measure your transmitter output power and antenna VSWR *at the feedpoint.*

*The 70-cm *EME Newsletter* is published monthly by Allen Katz, K2UYH, 326 Old Trenton Road, RD 4, Trenton, New Jersey 08691. A sample copy is available for a business sized (No. 10) envelope with 1 ounce postage.

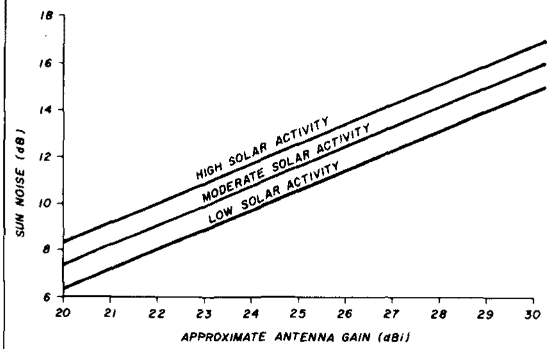

fig. 4. Approximate antenna gain as a function of sun noise referenced to cold sky. Frequency is 432 MHz, noise figure is approximately 1 dB, and side/grating lobes are less than − 13 dB.

Caution: Do not stand in front of the antenna with transmitter power applied, since your body may absorb hazardous levels of rf radiation.

The sun is a convenient signal source for testing receiver sensitivity as well as antenna gain. **Fig. 4** has been prepared only as a crude guide to assist you in this test. First set your receiver to the CW/SSB mode, remove the AGC and noise limiter and select a wide (2 or 3 kHz) bandwidth. Then measure the receiver audio output with a dB meter while making sure the receiver system is not in compression. Next aim your antenna to a cold spot in the sky; that is, away from the sun, local objects, the ground, or the galactic plane, and note the dB meter reading. Then aim your antenna at the sun and peak for maximum sun noise (note: maximum noise should be right on boresite. If not, you may have antenna phasing errors.) For example, with a reasonable noise figure and an antenna-mounted preamplifier (as described earlier) and moderate solar activity (1981), a 25-dBi antenna should yield about an 11-dB noise increase between the cold sky and the sun. It is best to compare your measurements with a similar station on the same day and time for better accuracy. Note that when the sun drops below 10 dB, it no longer drops in a linear fashion.

summary

I have tried to cover a lot of bases and naturally I have probably missed some. Many of us have spent five or ten years or more, and a lot of time and money, trying to perfect our stations and operating techniques. The purpose of this guide is to help you avoid some of the pitfalls by telling you things that have worked for other 70-cm operators. There may be other ways to go, but I believe this information is the path to success with the least number of prob-

lems. I would particularly like to thank Lewis Collins, W1GXT, and Allen Katz, K2UYH, for their review of this article and thoughtful suggestions. Good luck. See you on 70-cm EME soon.

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Notes:

1. Requests for additional information can be made to the author but they will not be answered without an SASE.
2. This publication had limited distribution but copies are available (note 1).
3. EIMAC EME notes can be obtained by writing William Orr, W6SAI, c/o Varian, EIMAC, 301 Industrial Way, San Carlos, California 94070.

ham radio

A look at
the future of
slow-scan television

applying microcomputers to SSTV

Slow-scan television (SSTV) is a medium for transmitting still pictures via Amateur Radio. It is almost identical to facsimile in concept. The standards commonly used in Amateur SSTV are listed in **table 1**.

table 1. Amateur slow-scan standards (from the *ARRL Handbook*).

	60-Hz areas	50-Hz areas
sweep rates:		
horizontal	15 Hz (60 Hz/4)	16-2/3 Hz (50 Hz/3)
vertical	8 sec.	7.2 sec.
No. of scanning lines	120	120
aspect ratio	1:1	1:1
direction of scan:		
horizontal	left to right	left to right
vertical	top to bottom	top to bottom
sync pulse duration:		
horizontal	5 millisec.	5 millisec.
vertical	30 millisec.	30 millisec.
subcarrier frequency:		
sync	1200 Hz	1200 Hz
black	1500 Hz	1500 Hz
white	2300 Hz	2300 Hz
required transmitter bandwidth	1.0 to 2.5 kHz	1.0 to 2.5 kHz

table 2. Digital picture transmission header. Each byte contains eight bits.

item	no. bytes	code
sync vector	4	binary
receiving-station callsign	10	ASCII
sending-station callsign	10	ASCII
horizontal resolution	2	binary
vertical resolution	2	binary
colors	1	binary
luminance	1	binary
spare	2	
total	32	

This article presents some ideas on how microcomputers can be used to improve this mode of Amateur communications.

background

Fig. 1 depicts three generations of an Amateur SSTV receiving setup. In the early days of SSTV, the picture was displayed on a cathode-ray tube having a long persistence. Once the novelty of receiving pictures had worn off, the display was seen to be crude and inconvenient. The tube had to be viewed in a darkened room. The picture was updated slowly (every eight seconds) and faded rapidly. Most people, in fact, photographed the picture and viewed the photograph rather than the screen. The second generation of SSTV equipment incorporated scan converters. These are relatively expensive, but convert the SSTV pictures into a form displayable on a standard fast-scan TV monitor.

The advent of the microcomputer introduces the third generation of SSTV equipment, which will improve the capabilities of the medium by at least an order of magnitude. It will allow image-processing techniques to be used to cut down the effects of interference, and it will allow real-time color displays using a field-sequential color transmitting scheme.

Basic SSTV equipment comprises a picture source and display. Many Amateurs, when first entering the mode, purchase a display and generate a tape recording on a friend's system to use as a video source. Later, as funds permit, they add cameras, electronic pattern generators and other signal sources.

the microcomputer and SSTV

The microcomputer can be added to the SSTV sta-

By Joe Kasser, G3ZCZ/4X, Mercaz Klita 49A, Mevasserret Zion, Israel

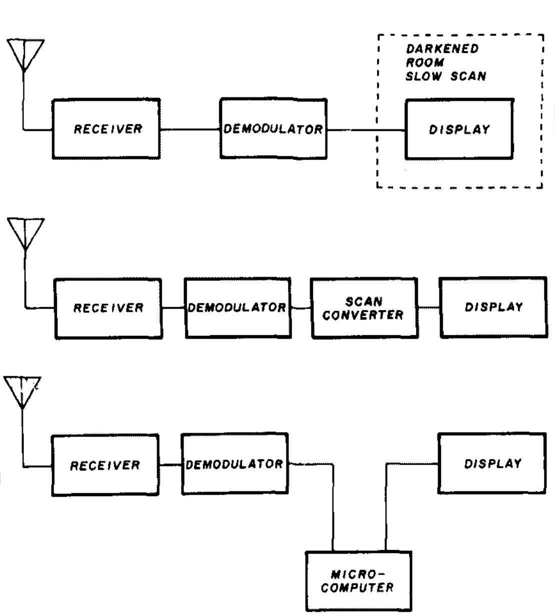

fig. 1. First, second and third generation slow-scan TV receiving arrangements.

tion in stages. It can be used to generate patterns or characters. For example, it can display any characters typed in at the console. It could digitize and scan convert incoming pictures. A picture library could be built up on floppy disks. Then, as image processing software is added, interesting things begin to happen. Initially, the use would be to compensate for interference on received signals. Simple techniques (algorithms), such as displaying the average picture received over a number of sequential frames, could be used. Gray-scale adjustments could be made. A whole picture editing system could be developed using the console or a light pen or both as control inputs.

Color could be added if three pictures (red, blue, and green) can be stored separately and combined in the display. A fast-scan display at the system console makes the pictures much more viewable. Later additions to the software could include overlaying one picture upon another, merging pictures, or merging sections of different pictures. A picture of a person could be overlaid onto different backgrounds. Composites could be built up. Data could be added to annotate the picture. The narrow bandwidth of the transmission medium, as well as the visual impact of the display when used with the microcomputer, have the potential to make SSTV as popular as SSB voice in the Amateur field. It offers new capabilities in other areas such as law enforcement, whereby pictures of suspects (stored in computers) could be transmitted via conventional VHF/UHF voice quality links.

color

Slow-scan color may be transmitted using a field sequential technique. The picture to be transmitted is separated into blue, red, and green components. Each component is transmitted as a separate picture frame and assembled at the receiving station into a color picture. The transmission of one slow-scan color picture thus requires three frames.

Transmission is quite simple because the regular station camera can be used. Color separation is performed by inserting a filter between the camera and the subject. Three filters are required: green, red, and blue. The filters can be cemented to a disk and rotated by a stepping motor, so that the disk is advanced one filter band for each field sync pulse, as shown in **fig. 2**. The more filter bands present on the disk, the fewer steps the motor must sequence to switch colors. This simple technique allows the transmission of live color pictures, but ignores the problem of the receiving station deciding which frame is allocated to which color. This problem can be resolved by always transmitting the colors in the same sequence and verbally announcing which color is coming first, or by transmitting some kind of color-reference synchronizing signal. Since color slow-scan television is still in its infancy, these standards still have to be worked out.

digital slow pictures

Videographic displays and digital communications can be merged to provide picture transmission

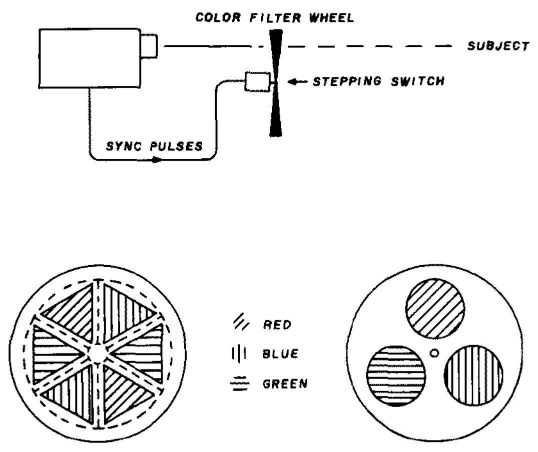

fig. 2. Color filter-wheel possibilities. Filters may be cemented onto a disk, which is rotated by a stepping motor so that the disk is advanced one filter band for each sync pulse.

capabilities. A videographic display causes the contents of a memory area in the computer to be displayed on a TV screen. The display may be color or black and white with gray scales. If the contents of a display memory in one computer can be transmitted to the display memory of another one, a picture will have been transferred.

If two Amateur Radio stations have the same video display hardware, the transfer of the contents of the video memory in one computer to the other one in effect transmits a picture from one station to the other. If the displays have 1024 x 1024 pixel resolution with color and luminance, then a very high-resolution picture can be transmitted, although at a slow rate. The majority of videographic displays at this time have resolutions of the order of 128 x 128 or 256 x 192, and so forth. Some may be color, some may be black and white, and some may be color but viewable as black and white on a black and white monitor. Now it is desirable that anyone with a graphics video display capability in his computer should be able to transmit and receive pictures if a suitable modem is available.

transmission format

The digital format of transmission means that any format could be used providing that suitable software exists. To avoid resolution problems, it is desirable that the formats be compatible with all kinds of displays, a situation that is hardly likely to occur in practice.

The digital format is really a digitized analog signal. Thus, a zero level, or a sync pulse level will always be a 00 signal and a very bright signal would always be an OFF Hex or a maximum. If signals are transmitted in consecutive lines with a header in the first line, format independent pictures can be transmitted. The header would contain the data as shown in **table 2**.

The sync vector of four bytes synchronizes the system and notifies the receiver that a header is coming. The callsigns of the sender and recipient are then transmitted in the next 20 bytes. Ten bytes are sufficient for 99.9 percent of the Amateur Radio callsigns allocated today. GW3ZCZ/KH6 is only ten bytes long, for example.

The next two bytes contain in binary code the number of pixels per line, followed by two bytes that contain the number of lines in a frame, also in binary. One byte each is allocated to color and luminance information. The color byte could be an ASCII R, G or B to signify which frame of a field-sequential color picture is being transmitted or any other information. The luminance byte contains information about how many gray levels are present in the picture. Two spare bytes are allocated at this time to bring the byte count to 32.

fig. 3. Digital line transmission format. A sync vector synchronizes the receiving-station software, the pixels are transmitted, and the sync vector is again transmitted to ensure that the receiver stays in sync with the transmitter.

picture information

A sync vector synchronizes the receiving-station software (**fig. 3**) and the pixels are then transmitted. The number of pixels is known from the header, and when the line is completed, the sync vector is again transmitted to ensure that the receiver stays in sync with the transmitter. When a whole frame has been transmitted, the sequence may stop, or another frame may be transmitted.

The picture transmission has been defined in terms of memory-to-memory transfer. If both stations have identical videographics hardware, they can display the same picture. What happens, however, if the second station does not have the same hardware as the first?

If the receiving station has hardware with the same resolution as that of the transmitting station, the same picture can be displayed. If color or luminance are the same, they will be lucky. If the receiving station does not have color, it will probably be able to display a black-and-white picture.

If the receiving station has a resolution different than that of the transmitting station, a number of choices are open. Assume that the picture being transmitted is 256 x 256 pixels, and the receiving station has a 128 x 128 display. The receiving station has a number of options. The first option is to perform some kind of signal processing on the picture data to combine two pixels in both horizontal and vertical directions to reduce the resolution of the picture. This will allow the whole picture to be displayed, but at a lower resolution. The remaining options are shown in **fig. 4**. Here a reduced area of the picture is displayed. A corner, as shown in **fig. 4A** or a middle section, as shown in **fig. 4B** may be chosen. This technique is sometimes used to zoom in on selected portions of a high-resolution picture. As the display options are in software, the receiving station has a choice of how to display the picture.

If the receiving system has better resolution than that of the sending station, similar techniques can be used either to display the picture in a part of the screen together with other desired information (such as callsigns) in the remaining portions of the screen, or the picture information can be doubled both

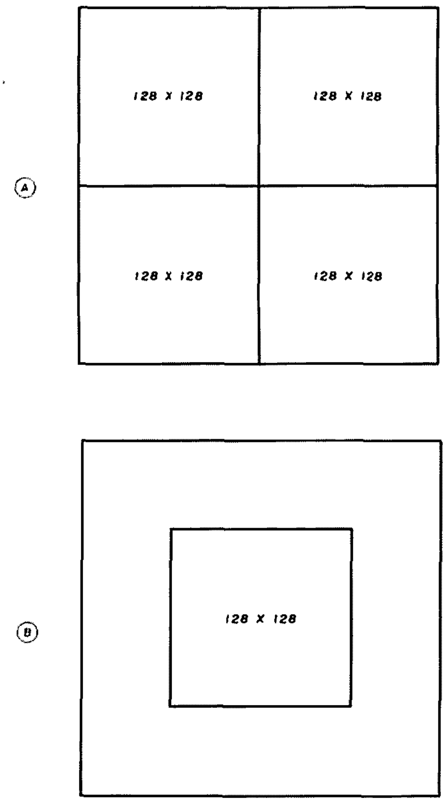

fig. 4. Lower-resolution receiving options. In this example, the transmitted picture contains 256 × 256 pixels, and the receiving station has a 128 × 128 display capability. A corner, as in *A*, may be chosen — or a middle section, as in *B*.

horizontally and vertically to fill the screen. If the receiving station has a 256 x 192 resolution for example, the choices can be applied to the vertical portion only.

The picture has been transmitted as a memory-to-memory transfer. The software in the receiving station can thus decide if processing must be performed for the display. The processing can be performed on the picture as it is received in systems with minimal amounts of memory, or the picture can be stored in memory and moved to the video display area by the processing algorithm.

The mode of transmission of the digital data can be ASCII, RTTY, or packet, depending on what is available to the users. The use of digital transmission formats for slow scan television changes the meaning of "slow," for it no longer applies to low-resolution pictures but can now refer to the slow data rate for transferring a picture of any resolution.

ham radio

the radiation of radio signals

An explanation of how a radio transmitter puts a signal into space

What, exactly, is flying around when you key your rig? How does that high-frequency alternating current in the final amplifier tank circuit manage to propagate its effects far into space? We all have a vague idea of what happens, but misconceptions abound. This article will explain, in understandable but rigorous terms, how that signal gets to bounce around the world — and, perhaps, into the receiver of a rare DX station.

the antenna system

Of course, the antenna system is responsible for putting your signal into space. When speaking of the antenna system, we refer to two components: the transmission line and the antenna. The purpose of the transmission line, or feed line, is to get the signal from the rig to the antenna. The purpose of the antenna is to get as much of the signal as possible into space.

the transmission line

Rare is the station that uses no transmission line between the rig and the antenna. Of those few stations with antennas that run right down to the transmitter, rare indeed is the one without "rf-in-the-shack" troubles. The antenna, in performing its function of radiating the signal, will put some of that signal right into the shack unless the antenna is far enough away. The feed line allows you to put the antenna far away from the rig, so the signal will go where it should and not where it shouldn't.

How does the feed line transfer the signal? An alternating voltage is present at the input of the line,

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and this causes alternating currents to flow in the conductors. But the actual propagation of the signal along the line is not because of these currents and voltages themselves. It is not current, or voltage, or even power, that travels along the line. It is an electromagnetic field that travels.

Fig. 1 is a "stop-action" diagram of the currents and voltages, and the resulting electric and magnetic fields, in a short section of parallel-wire feed line. The currents in the two wires are equal in amplitude, but opposite in direction. A magnetic field (M) is produced around each conductor. A voltage exists between the two conductors, producing an electric field (E). The E and M fields vary in intensity as the currents and voltages alternate, but the fields are always perpendicular to each other. You should recall from high school physics that this situation produces a unique type of energy field, an electromagnetic field (EM). EM fields regenerate themselves in a sort of "leapfrog" manner, and thus they can travel great distances with much less attenuation than can either E or M fields by themselves. The EM field travels in a direction perpendicular to both the E and M fields. From **fig. 1**, we can see that this direction runs right along the transmission line. The voltage at the line input causes an EM field to propagate down the line away from the rig. This field is restricted to the immediate vicinity of the conductors because it can travel only exactly in line with them. Hence the line does not radiate, and serves as a sort of guide for the EM field.

Fig. 2 shows what happens in a coaxial line. The E and M fields, although confined to the inside of the cable, are still perpendicular at every point. The EM field is thus produced in line with the cable. It can't escape the outer conductor, and so it is entirely confined within the dielectric material in the coax.

how fast does it move?

Electromagnetic fields travel at the speed of light — about 300,000,000 meters per second in a vacuum. Through air, they travel about 97.5 percent as fast as they do in a vacuum. EM fields travel more slowly through dielectric materials (non conductors) such as glass or polyethylene. In solid polyethylene they go about 66 percent of their speed in a vacuum; in foamed polyethylene the figure varies between 75 and 80 percent. The velocity factor for a given material is the ratio of the speed of the EM field through the material divided by the speed through a vacuum.

Since commercially prefabricated feed lines usually have either a foamed or solid polyethylene dielectric, the speed of EM fields along such lines is somewhat less than their speed in free space. In a coaxial line, all of the EM field is confined to the dielectric material. In a two-wire line, such as TV ribbon, some of the EM field travels through the dielectric and some travels through the air near the line. Thus, the

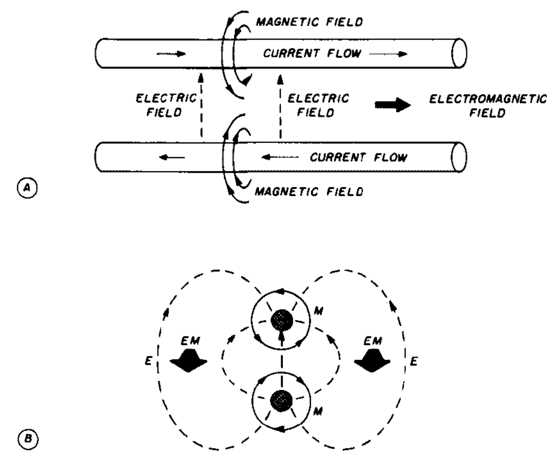


fig. 1. Generation of an EM field in a parallel-wire transmission line. Thin arrows represent currents in the conductors. The dotted line shows the electric (E) field and the curved lines show the magnetic (M) field. *A* is a side view; *B* is the view along the conductors. The heavy arrow represents the EM field, which travels along the conductors in their immediate vicinity. Because the EM field can move only parallel to the conductors, the line does not radiate as long as the currents in the conductors are equal in magnitude and opposite in direction.

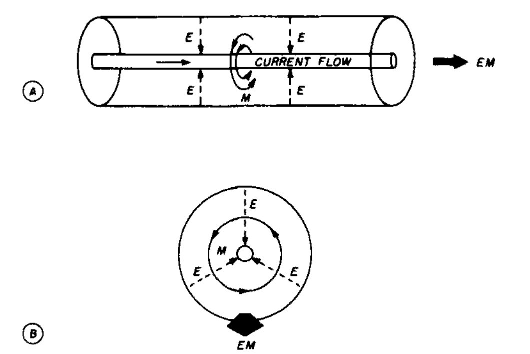


fig. 2. Generation of an EM field in a coaxial line. *A* is a side view (assuming transparent shield material); *B* is the view along the line. As in *fig. 1*, thin arrows represent current in the center conductor, dotted lines represent E fields and curved lines represent M fields. The heavy arrows show the direction of the EM field. The fields are entirely confined to the inside of the cable, assuming a solid tube of metal constitutes the shield. With braided shielding, as is used in most commercially made line, a tiny amount of the EM field "leaks out," but it is insignificant.

velocity factor for two-wire line is usually greater, for a given dielectric material, than it is for coax. **Table 1** shows the velocity factors of several common types of transmission line.

table 1. Surge impedance and velocity factor for common types of transmission lines used by Amateurs. In the line type column, SP stands for solid polyethylene dielectric and FP stands for foamed polyethylene dielectric. The term open wire refers to parallel-wire line where the dielectric is predominantly air.

line type	Z_0, ohms	velocity factor
open wire, no spacers	70 - 800	0.975
open wire, plastic spacers	70 - 800	0.95 - 0.97
RG-8/U, SP	52	0.66
RG-8/U, FP	52	0.80
RG-58/U, SP	52	0.66
RG-58/U, FP	52	0.80
RG-59/U, SP	73	0.66
TV twinlead, SP	300	0.82

characteristic impedance

Suppose, for a moment, that the transmission line extending from the transmitter is infinitely long, so that a signal will continue along it without end. Suppose also that the conductors and dielectric material have no loss, so the signal will remain at the same intensity forever. As the EM field travels down the line away from the rig, there is a certain current (I) in the conductors, and a voltage (E) across them. The product EI is equal to the transmitter output power. The ratio E/I depends on the size and spacing of the feed-line conductors, and also on the nature of the dielectric material. For a two-wire line, the ratio E/I may be as low as about 70 or as high as about 800; for coaxial line it ranges between roughly 30 and 100. The ratio E/I is called the characteristic, or surge impedance, of the line. It is abbreviated Z_0.

Of course, a real feed line has some loss. Because of loss, we will observe that both the voltage and current decrease as we get farther away from the rig. However, their ratio will stay the same, since the Z_0 of the line is constant.

Naturally, it is impossible to have a line that is infinitely long. Suppose that the line is terminated by a resistor at the far end, whose value in ohms is equal to Z_0. Then when the EM field arrives at the resistor, it will all be absorbed and dissipated as heat. This situation is encountered in practice when we connect our rigs to matched "dummy loads."

radiation resistance of the antenna

Putting a resistor at the far end of a transmission line won't do much if we want to get on the air. We usually want the EM field to be radiated, not used up heating resistors!

If we put the right kind of antenna at the far end of the line, the EM field along the line will behave exactly as it does when the line is terminated by a resistor with an ohmic value of Z_0. In radiating the EM field, all antennas seem to display a certain resistance. This resistance is called the radiation resistance (R_R) of the antenna. In order for an antenna to radiate all of the EM field arriving from the feed line, R_R must be equal to the line Z_0, and the antenna must also be resonant at the operating frequency. If both of these requirements are not met, some of the EM field will be reflected back toward the rig. This complicates the pattern of voltage and current along the line. We'll look at this in more detail shortly.

The R_R of an antenna is a function of its physical length in wavelengths. This function is illustrated by **fig. 3**. A half-wavelength dipole in free space, fed at the center, displays a radiation resistance of about 73 ohms. As far as the EM field on the transmission line is concerned, this kind of antenna is just like a 73-ohm noninductive resistor (of sufficient power-handling capacity!). But of course there is quite a difference once the field gets to the antenna. A resistor condemns the field to an unceremonious death; the antenna sets it free.

into the antenna

Once the EM field has completed its journey from the input end of the feed line to the antenna — a matter of nano- or microseconds — it is ready to be radiated. If we're lucky enough to have a perfect match between Z_0 and R_R, along with resonance, the situation is fairly simple. So for now we'll make that assumption.

Once the field reaches the antenna feed point, it continues outward along the antenna wire. But, while the fields were forced to move straight along the feed line, they are not restricted to any particular path once they get to the antenna. **Fig. 4** shows the configuration of the EM fields in the vicinity of a dipole. The E and M fields exist in a rather complicated pattern that allows some radiation in all directions, except exactly in line with the wire, where no E or M fields exist. The greatest EM field intensity is in directions perpendicular to the wire.

into space

Once the EM field has left the antenna, it will propagate into space in ever-expanding wavefronts. How effective is an antenna in radiating EM energy? That depends on many things: the resistance of the conductors in the antenna, obstructions near the antenna, the height of the antenna above ground, and the

physical length of the antenna. We can control all of these factors. But we can use conductors that are only so hefty; we can put the antenna up only so high. Ultimately, the efficiency of a common dipole can be made almost 100 percent. But there will always be some loss of signal. The efficiency of an antenna system, mathematically, is given by:

$$Eff = (P_T - P_L)/P_T$$

where P_T is the transmitter output power and P_L is the power lost in the feed line, antenna, and surrounding obstructions, including the ground. The power $P_T - P_L$ is given up as EM radiation.

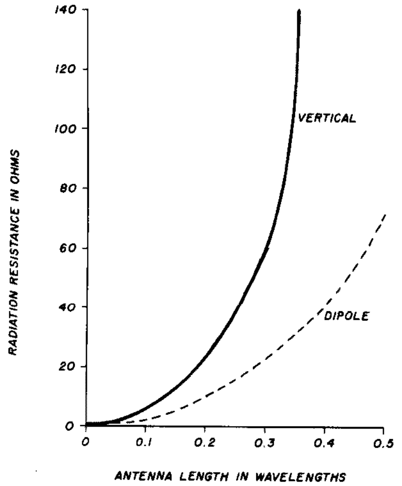


fig. 3. Radiation resistance of antennas as a function of length. The solid line represents a vertical antenna over a ground plane; the dotted line represents a dipole fed at the center. The data is for antennas without nearby obstructions. This graph is adapted from information in *The ARRL Antenna Book*, 13th Edition, 4th Printing, 1977, page 60.

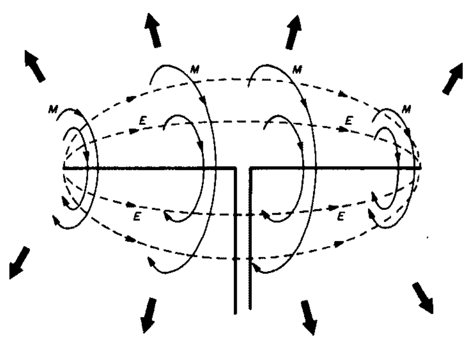


fig. 4. Radiation of EM field from a dipole antenna. A two-wire feed line is shown. The M field, produced by the current in the antenna wire, is shown by the solid circular arrows. The E field, caused by the voltage difference between different points in the dipole, is shown by the dotted lines. Heavy solid arrows show the direction of EM field radiation. EM radiation occurs in all directions except right along the axis of the wire; the greatest amount of EM radiation is in directions perpendicular to the wire.

standing waves

Usually, the line Z_0 and the antenna R_R are not exactly equal, or the antenna is not exactly resonant at the operating frequency. In this case, when the EM field arrives at the antenna feed point, some of it will be reflected back toward the transmitter. The proportion of the EM field that is reflected depends on the severity of the mismatch; the greater the mismatch, the more of the EM field is reflected.

When the reflected EM field gets back to the rig, it is all re-reflected toward the antenna.* When this re-reflected field arrives again at the antenna, it will be reflected partially again, in the same proportions as on its first encounter with the feed point. This process will continue on and on, until line loss reduces the reflecting EM field intensity to practically zero. (This usually takes only a few microseconds.)

The total EM field received by the antenna is the sum of the EM fields received on each encounter.

The reflecting EM fields produce an interference pattern in the voltage E and the current I along the feed line. Instead of being uniformly distributed, there are points of current and voltage minima and maxima. The more severe the mismatch, the worse this nonuniformity. If the mismatch is bad enough, the current may get so high that the conductors overheat and melt the dielectric material. Or the voltage may get so high that an arc occurs and puts a hole in the dielectric. This increase in E and I causes the overall temperature of the feed line to rise, the result of loss in the line under mismatch conditions. This loss may or may not be enough to matter in practice.†

The voltage standing-wave ratio (VSWR) is the ratio of the maximum voltage to the minimum voltage along a feed line. If the VSWR is 1, the voltage is the same all along the line. If it is 3, then the maximum voltage is three times the minimum voltage. We can measure VSWR in a transmission line with rf voltmeters at various points, or with a reflectometer such as the common SWR indicator.

It is commonly thought that the transmission line transfers *power* from the transmitter to the antenna, and that some power is reflected when the line and antenna are not perfectly matched. In fact, many

*Assuming the transmitter is tuned properly.
†Gibilisco, "How Important is Low SWR?", *ham radio*, August, 1981.

SWR meters actually have "forward" and "reflected" power scales calibrated in watts. But the feed line is not really transferring power; it is the EM field that moves along the line. The currents and voltages in any feed line are always alternating back and forth; to say that these currents and voltages, or the power represented by their product EI, is going "forward" or "backward" in any continuous manner, doesn't really make any sense. If the SWR is such that a reflectometer shows 100 watts "forward" and 25 watts "reflected," this means that the forward-moving EM field is four times as intense as the backward-moving EM field. It also tells us something about the relative intensity of the fields; if we reduce the transmitter drive the meter readings might change to 80 watts "forward" and 20 watts "reflected," or some other 4-to-1 ratio.

conclusions

The dipole antenna of **fig. 4** has its own characteristic radiation pattern. Other antennas have different radiation patterns, but they all have been designed to radiate an EM field.

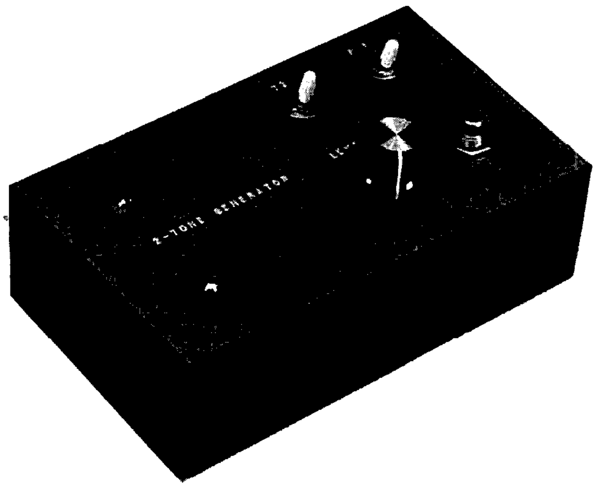
All transmission lines share the property of being good carriers, but poor radiators, of EM fields. Sometimes, however, if an antenna system is not properly designed, the feed line can allow quite a lot of signal to be radiated. Improper balance is the most common cause of feed-line radiation. Of course, we can deliberately design an antenna system so that part or all of the transmission line radiates.

Once the EM field has left the antenna, we no longer have control over where it will go, or whose receiving system it might end up in. The frequency band we use will give us a certain amount of choice as to where the EM field can go (on 2-meter FM it probably won't be heard in India); but we cannot choose, within its characteristic range, whose receiver it will enter and whose it will not. If someone wants to hear our signal, and he's in range, then he can tune it in.

On some frequencies, our signal escapes through the ionosphere into outer space. Theoretically, it goes on forever. One of the bands where this happens is 2 meters. Perhaps a few centuries from now, on a planet orbiting a distant star, some scientists may be experimenting with their first radio-communication devices for VHF. They may be just discovering fm. They may tune in your transmission, boosted by the help of your local repeater. They may have had, from previous hf experiments, exposure to our potpourri of rf energy, and they may have deciphered our languages.

How will they react to the news that traffic is flowing smoothly on I-95?

ham radio

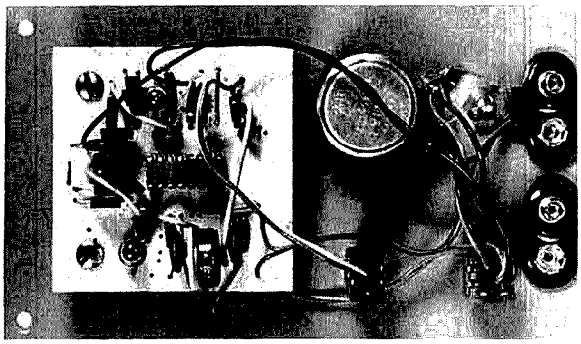


Using inexpensive parts you can build this device in only a few hours

a simple two-tone generator

Today's integrated ham stations include sophisticated accessories such as an oscilloscope for signal monitoring. Usually not included, however, is the two-tone generator needed to test a single sideband (SSB) transmitter and its linear amplifier. A suitable generator can be constructed in a few hours from inexpensive parts.

A single tone injected into the microphone jack of an SSB transmitter will produce CW rf output. Adding a second tone will produce rf output on two frequencies. These two frequencies, when viewed on an oscilloscope, will produce an interference pattern. If one or more stages in the transmitter are nonlinear, new frequencies that are products of the original two will be generated. These new frequencies will modify the oscilloscope pattern perceptibly. Thus, a two-tone generator and a 'scope are the primary tools needed to test and evaluate SSB equipment.



The main portion of the two-tone audio generator is constructed on a universal circuit board. The pc board is mounted via two ½-inch stand-off posts. The output control, switches, and output jack are mounted on the aluminum panel from an "experimenter" box.

circuit description

The heart of the generator is a Wien bridge audio oscillator. This circuit was first described in Amateur literature in the early 1950s. It uses two resistors and two capacitors to establish an audio frequency. A nonlinear resistance (an incandescent lamp) in a feedback loop stabilizes operation and reduces harmonic content.

One problem with some Wien bridge designs is that they often call for unusual lamps that are often

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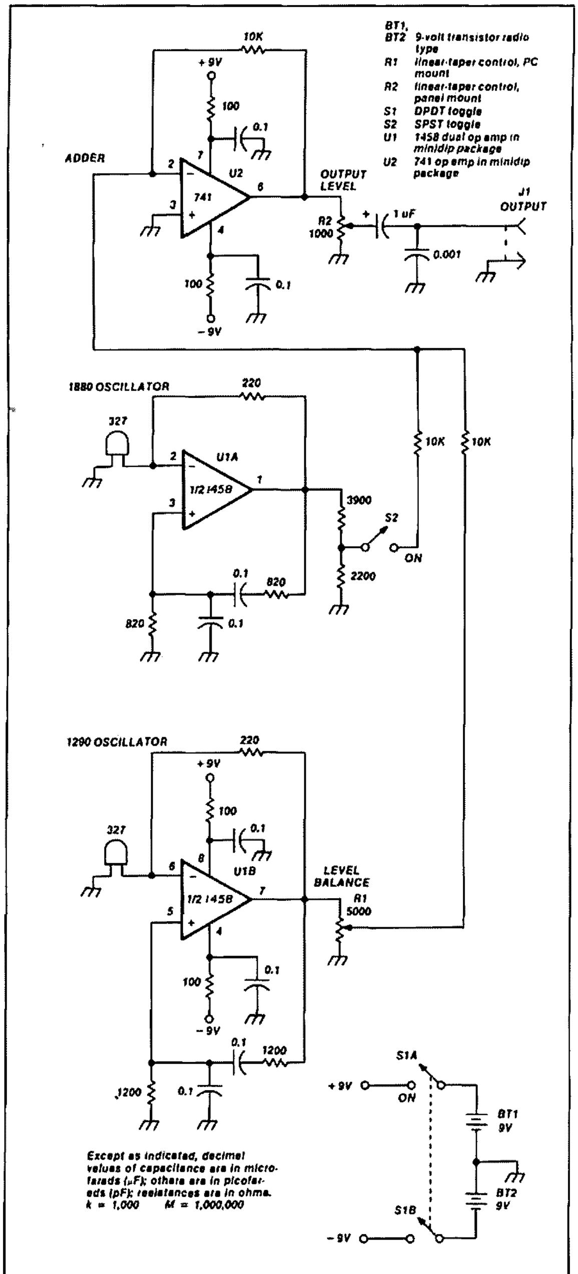


fig. 1. Circuit diagram of the two-tone generator.

difficult to obtain. An exception is the circuit which has appeared in the *ARRL Handbook* in recent years; it uses the 327 bulb, a 24-volt lamp widely used in telephone equipment.

The circuit for the two-tone generator is shown in **fig. 1**. The ever-popular 741 op amps are used for the active elements. (The 1458 is the dual version of the 741.) The frequencies of the two oscillators were chosen to fit standard component values. Other frequencies can be employed; they should be between 500 and 2000 Hz and should not be harmonically related.

The output level of U1A is set by a resistive divider, while the output of U1B is adjustable in amplitude through R1. The output of the two oscillators is combined in U2, an op-amp adder with unity gain. The output from U2 can be adjusted using R2.

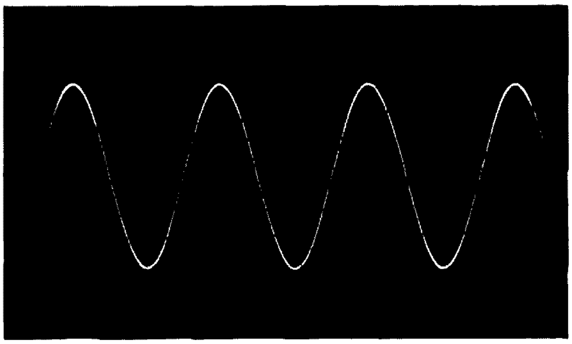
Power for the generator is provided by two 9-volt transistor radio batteries. The power leads to the op-amp packages are decoupled with 100-ohm resistors and 0.1μF capacitors. These components are required to ensure stable operation. The 741-type op-amps are available in single, dual, and quad packages. A quad package can be substituted for the single and dual used in **fig. 1**, or three singles can be employed, with appropriate changes in component arrangement.

construction

The generator is assembled on a universal circuit board. The board was cut in half, with the second half relegated to the "junk box" for a future project. The parts layout of fig. **2** was employed. Holes were drilled for all component leads with a No. 60 bit. (Be sure to mount the drill bit well down into the chuck, as it is easily broken.) Parts can be tack soldered to the isolated pads rather than drilling holes, but this assembly procedure is somewhat lacking in neatness.

Before any parts are mounted, the circuit board should be brushed with fine steel wool until all pads are bright and shiny. Then, mount the components a few at a time, bending the leads slightly to hold the components in place. Solder each connection, making sure to use sufficient heat so that the solder flows freely. Any solder joint that appears dull or matted should be reheated.

The two-tone generator can be housed in any metal or plastic housing of sufficient size. A coat of paint for the box and a few decals will improve the



Output from a single oscillator shows a "clean," low-distortion sine wave.

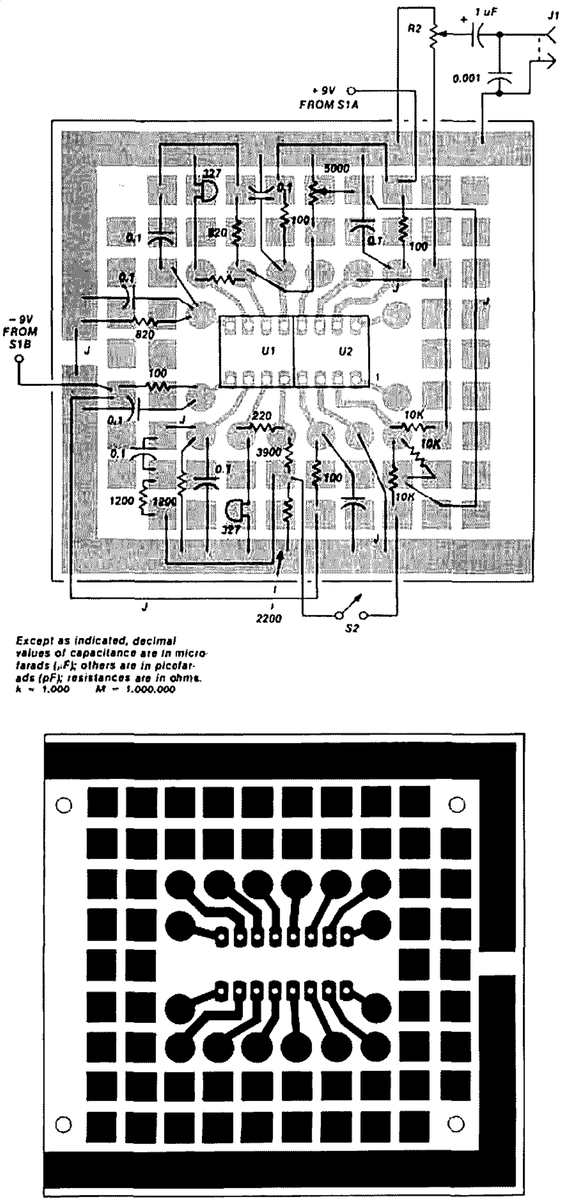


fig. 2. Component layout for the audio generator.

appearance of the finished product.

Only one adjustment is required for the unit — to balance the two tones for equal amplitudes. Adjust R1 for zero output from U1B. Close S2, set R2 at mid scale, and observe the level of audio at J1 using an ac voltmeter or an oscilloscope. Record the reading. Open S2 and adjust R1 until an identical level is obtained. The two tones are now of equal amplitude, and your unit is ready for use.

ham radio

the hybrid coupler

Evolution of and practical applications for a versatile circuit

Originally, the term *hybrid* was telephone company shorthand for *hybrid coil* or *hybrid transformer*. This device was invented (before the development of vacuum-tube amplifiers) to make it possible to put amplifiers in a two-way telephone line. A similar use is found in some phone patches.

The coil of **fig. 1** is such a hybrid — if **C** and **D** feed identical lines; and if the amplifier input is connected to **B**, and the output to **A**, then any signal coming from **C** will be amplified and sent out to **C** and **D**. In the case of a trancontinental system, **C** will get a strong echo, but if **C** and **D** are close to equal impedance, the amplifier will not "sing" (oscillate). It's similar to a Wheatstone bridge, except that the center-tapped winding eliminates two resistors and their power losses.

The point is, the network has four ports (terminal pairs). With matched loads on any three, the fourth is matched; and with matched loads on the two others, opposite ports are not coupled (are isolated). **Fig. 1** shows the circuit of a 2 to 20 MHz ferrite-core transformer hybrid, called a 180-degree type.

Fig. 2 shows a coax-cable equivalent (at a single frequency).[1] If there are 50-ohm loads on **C** and **D**, then power into **B** will be divided between them equally, and the input impedance at **B** will be about 50 ohms. If a dummy load (50 ohms) is put on **A**, we have an in-phase power divider, in which **C** and **D** are isolated from each other; that is, shorting out **C** will not affect the signal delivered to **D**. If **C** and **D** feed two receivers from a common antenna or preamp coming in at **B**, the local oscillator radiation from the receiver at **C** will be considerably attenuated at **D**. The two arms feeding **A**, and the load, provide the isolation without absorbing any of the input power. When the 70-ohm lines are not a quarter and three-quarter wave, say ten percent off frequency, it doesn't work as well.

Now suppose this 50-ohm 180-degree hybrid has a quarter wave of 50-ohm line added on (this will work only at one frequency, but that's OK for hams), as in **fig. 3**. The power still divides between **C** and **D′**, but they are 90 (or 270) degrees out of phase (depending on how you measure); that is, in quadrature. At the frequency chosen, this is known as a *quadrature hybrid*, one of many kinds.

an experiment

Let's put two identical 20-ohm loads on the ports **C** and **D′**. That means that power will be reflected

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from each load (about 18 percent), but the reflection from **D′** occurs 180 degrees later than it would have without the quarter-wave line. The result is that a signal from **A** will show up at **B** after being reflected; or if the signal were coming from **B**, it would show up at **A**. The isolation between **A** and **B** is degraded

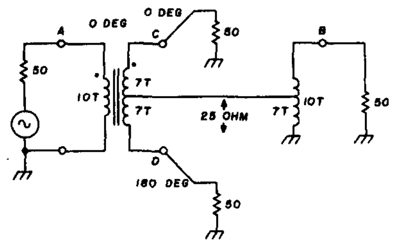


fig. 1. A 2- to 20-MHz 180-degree hybrid using a ferrite-core transformer.

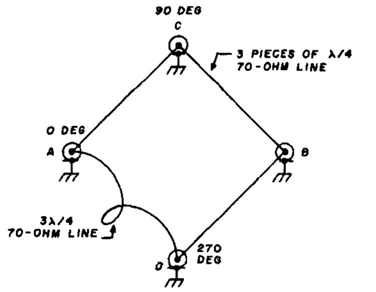


fig. 2. A coaxial-cable equivalent of the hybrid shown in *fig. 1* (narrowband type). Line lengths shown are important for optimum operation at a single frequency.

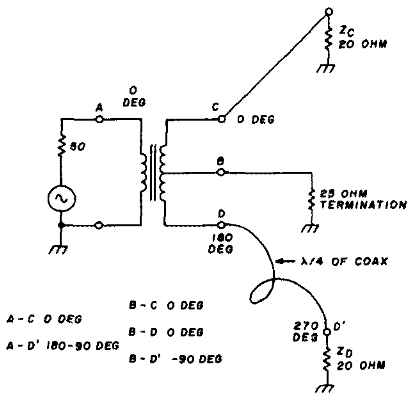


fig. 3. One example of a 90-degree, or quadrature hybrid. The reflections from Z_C and Z_D cancel at *A* and add at *B*. A 1:1 VSWR is presented to *A*.

by the mismatch, but if the added line is an exact quarter wave, the reflection at **A** is cancelled. If and only if the mismatches at **C** and **D′** are identical, **A** still sees a good match.

The more common type of quadrature hybrid is most familiar to hams as a "directional coupler," which is used in measuring antenna power and VSWR.

the quadrature coupler

Fig. 4 shows schematically the type of directional coupler found in a Bird wattmeter. The loop picks up the magnetic field and the capacitive coupling of the loop to the center conductor picks up the electric field. If constructed right, these components add for a wave going down the coax one way and cancel for a wave coming back — that's why it's directional. **Fig. 5A** shows the same thing carried to the extreme — a quarter wave of main line and a quarter wave of "pickup loop".

Notice that in both cases the coupled signal comes out in the reverse direction. If the proportions are right, it's possible to get half the input power to come out the coupled port — and of course the main line has only the other half coming out. That's a "3-dB directional coupler." If the phase of such a loop coupler is investigated, it will be found that the coupled output is 90 degrees out of phase from the main-line output. Thus it's a *quadrature* coupler. It has equal power division and an isolated port, as in the circuit of **fig. 3**. Unlike that hybrid, however, the quarter-wave coupler works well from 2/3 to 4/3 of center frequency, which is two to one, or an octave. The capacitance between the two inner connections must be fairly high to obtain the 50-percent power split.

Some hybrids are made by printing strip conductors on either side of the dielectric, as in **fig. 5B**, and some are made by using solid strip with a thin dielectric sheet between, in a cast housing. Another type is built much like coaxial cable. Two wires are twisted together with a thin insulation between them, then Teflon covers the wire pair. The assembly is shielded by a copper wrap, braid or tubing. The trade name of

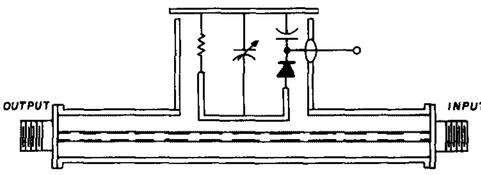


fig. 4. Version of the quad hybrid as a directional coupler used in the Bird wattmeter.

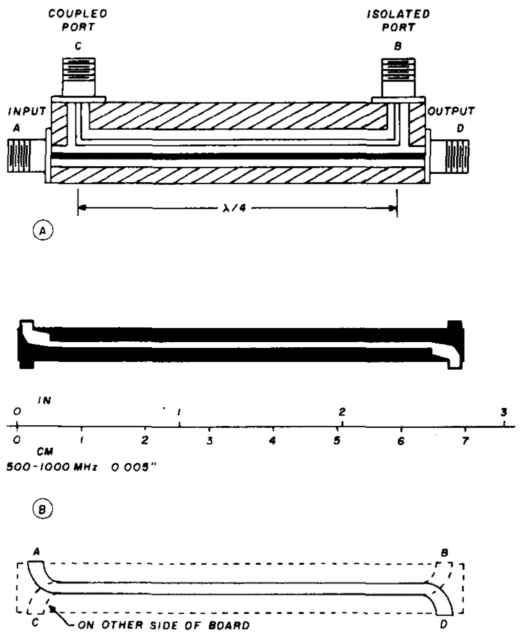


fig. 5. The directional coupler of *fig. 4* carried to the extreme, using a quarter wavelength of main line and a quarter wavelength of "pickup loop," *A*. In both cases the coupled signal comes out in the reverse direction. In *B* a hybrid is shown that is made by printing strip conductors on a fiber glass-filled teflon sheet.

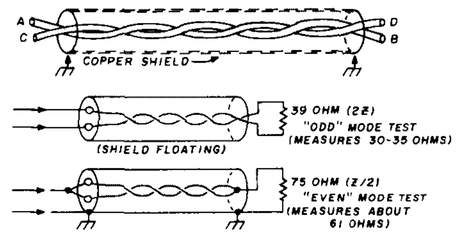


fig. 6. Construction of the Wireline® hybrid. Measurements were made using a Hewlett-Packard time-domain reflectometer.

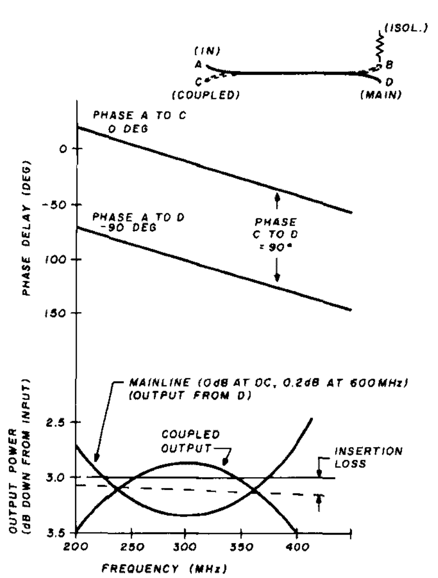


fig. 7. Response of a typical quarter-wave hybrid coupler.

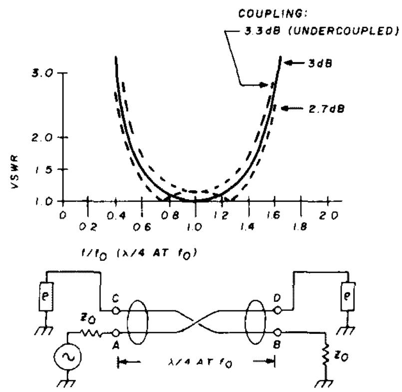


fig. 8. VSWR versus frequency for 100-percent (identical) reflections at the reflection coefficient point for a quad hybrid.

this hybrid is Wireline,* and the length can be cut for any frequency range as long as it's less than two to one.

Fig. 6 shows the Wireline® construction and shows how to check a length (if you make it yourself) with a time-domain reflectometer. The twisted pair should perform as a balanced 40-ohm line; while with the center wires shorted together, it should appear as a piece of 60-ohm coax.

*Wireline is a trademark of Sage Laboratories, Inc.

phase relationships

In case of a quarter-wavelength coupler (about 16 cm of Wireline® for a center frequency of 300 MHz), the voltage at the coupled port (the wire adjacent to the input, labled **C**) is approximately in phase with the input voltage at center frequency. The voltage at **D**, at the far end of the input line, is 90 degrees late and varies with frequency, as one would expect of a constant time delay. The phase between **C** and **D**, with a matched termination on the isolated port, is

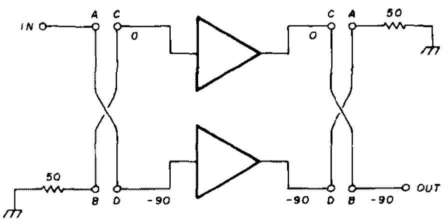


fig. 9. Two identical amplifiers in "parallel." Power gain and noise figure are the same as for one amplifier (except for hybrid coupler losses). Maximum input and output power is twice that of one amplifier.

almost exactly 90 degrees and independent of frequency as long as there is enough voltage to measure at the coupled output. This is shown, for a typical 3-dB hybrid, in **fig. 7**. It's true for any coupling factor for simple couplers. **Fig. 8** shows why a slightly overcoupled hybrid, such as that in **fig. 7**, is desirable for most applications.

some applications

Quadrature hybrids for VHF are made in various packages and frequency ranges, by a number of manufacturers. I'm familiar with Anaren, Anzac, Merrimac, Microwave Associates, Olektron, Sage (of course), and there are many others. The small size (you can get one in a TO-5 can) usually has a bit more loss, so if that's important get a big one. Some popular types cost as little as $15.00, but most are fairly expensive by ham standards.

For use at intermediate frequencies, such as would be required for a single-sideband up- or down-converter, a lumped-constant network may be handier. Anzac and Merrimac sell such devices, including ranges as wide as 2-32 MHz.

The obvious use for the quadrature hybrid is to combine a pair of power amplifiers (because of the isolation, one transistor failing won't cause the other one to blow), but the same layout is good for linear amplifiers (match is important for linearity) and for low-noise or broadband amplifiers (see **fig. 9**).

A balanced mixer is shown in **fig. 10**. This mixer is "balanced" in that noise in the local-oscillator is cancelled, and the local-oscillator fundamental is balanced out at the i-f port. A lot of local-oscillator power will come out the rf port unless the mixer is carefully adjusted, but the VSWR is good, and the noise figure can be excellent (that is, 6 dB) without much effort. The i-f port output impedance is about 100 ohms for 4 milliwatts of oscillator drive.

Quadrature hybrids (one for the local oscillator and one for the i-f) are needed to make the image-cancelled (SSB) mixer. One reason for wanting an image-cancelled mixer is that there has to be something that takes out the amplified noise at the image frequency that is coming from the rf stages. It could be an image filter (which will have loss, and may have to be retuned as you change frequency) or it could be a mixer in which the image response is suppressed by 16 dB or more. For moderate values of rf gain, the SSB mixer may give better over-all noise figure (and you can't measure the effect of image noise easily) than the best real filter, which has some loss.

make your own i-f hybrid

In **fig. 11A** the coil is a bifilar inductor, a transmission line (two wires, twisted a few turns per inch) wound on a coil form or a carbonyl-iron or ferrite toroid. The end-to-end inductance of one wire is the important parameter. The inductive reactance should be equal to 50 ohms at the frequency of interest, if you are making a 50-ohm coupler. Two capacitors are connected across the bifilar line at the ends, and the total capacitance (both capacitors plus the distributed capacitance of the twisted pair) should be the value that would resonate with that value of inductance. The coupling has a fast change with frequency, but it's useful over ten percent bandwidth. U.S. patent 3,452,301 probably covers these.

Two of the above couplers with a twin coax line between them (23 degrees at center frequency) make an octave-wide unit, as described by Reed Fisher, W2CQH. **Fig. 11B** shows a version with an artificial line (a lowpass filter) between couplers. Because the values are not very critical, the coils could be air-core types wound to calculated turns, or they could be set up with a grid dip meter. I had access to a *Q*-meter, which made it easy. (U.S. patent 3,452,300, assigned to Merrimac Industries, Inc.)

Fig. 11C shows how two quad hybrids and two commercial double-balanced mixers can be used to make an image-cancelled mixer. I built one at 1296

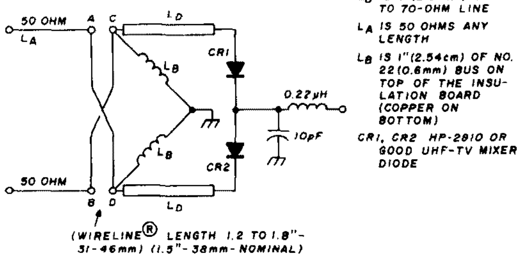


fig. 10. Mixer for 1296 MHz using the quad hybrid.

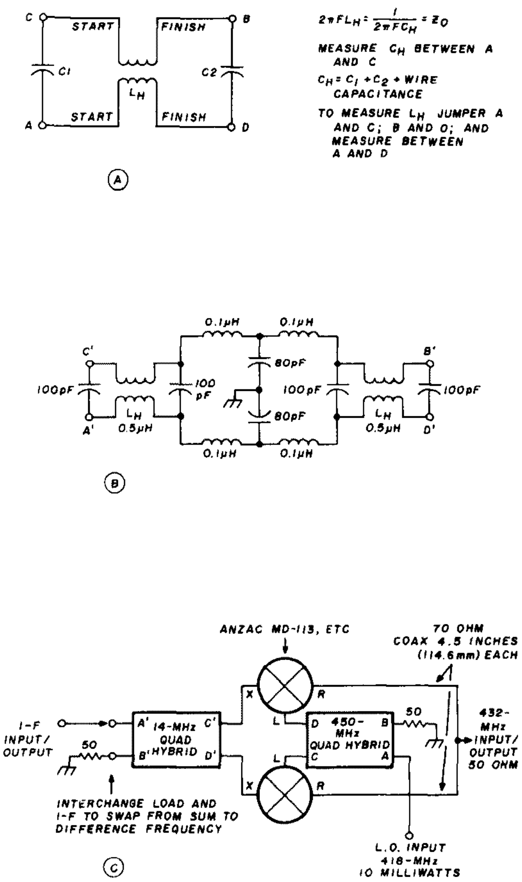


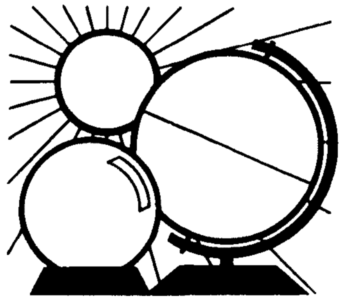
fig. 11. Practical uses for the hybrid. A 3-dB i-f hybrid is shown in *A*; a 12-20 MHz 3-dB hybrid in *B*; and an SSB mixer for 432 MHz in *C*. The 450-MHz hybrid can be Wireline® (any length from 3.6 to 5.6 inches, or 9 to 14 cm will work).

MHz for 14-18 MHz i-f, which had about 16-dB image ratio (0.107 dB of added noise from the image for a 2-dB rf stage). If the mixer noise figure were 7 dB, the image-cancelled arrangement would be as good as a perfect image filter with 0.8-dB loss, assuming 13-dB gain in the rf amplifier. (With two rf amplifiers, and 20 or more dB gain, the filter would be better, but where do you get a filter with 40-dB rejection 28 MHz away at 1296 MHz?)

references

1. Henry S. Keen, W2CTK, "Microwave Hybrids and Couplers for Amateur Use," *ham radio*, July, 1970, page 57. (Reprinted in *ham radio*, March, 1978, page 72.)

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

events of the month

Several interesting geophysical events occur on June 21st, affecting radio propagation and therefore DX. Lunar perigee is on the 21st at 1200 UT. The summer solstice occurs at 1723 UT. And there will be a partial solar eclipse from 1028 to 1340 UT.

The eclipse path is obscured 62 percent at maximum. It begins in the extreme south Atlantic Ocean, then moves on to South Africa and the Indian Ocean. Not many U.S. hams will be in the eclipse path, but our southern friends may find some lowering of maximum usable frequencies (MUFs) in the first half and some short-skip DX (from the ionospheric hole created) in the second half of the eclipse.

The full moon will be on the 6th of June. The solar activity and flux maximum is expected to be about the 18th. Solar-flare-induced geomagnetic/ionospheric disturbances may occur around the 14th and 22nd through 24th. Solar flux minimum is expected about the 5th through 8th and may be accompanied by a long geomagnetic disturbance from a weak coronal hole.

last-minute forecast

Solar-geophysical events translate into varying DX conditions throughout the month. The higher-frequency bands (10 and 20 meters) are expected to be excellent later, after the 15th, following a marginally good beginning. If 6 meters has openings at all, it will be Sporadic E propagation (Es) near midday. The solar cycle is far enough down from the minimum that the summertime ionosphere may not provide support for 50 MHz. The F region requires twice the density that the Es does to provide usable paths. The lower frequency bands (40-160 meters) should be the best during the first two weeks of the month. Noise (QRN) from summer thunderstorms may erupt in the evenings.

Since the Es propagation season is just now underway, let's have a look at some of its DX characteristics. In the major area for Es production and paths, south-east Asia, a frequency as high as 15 MHz will propagate continuously on a 2500-km east/west path twenty-four hours a day. During the hours of daylight into late evening, the F region mode propagates radio signals. Enough Es is then available to keep that frequency alive through the early morning hours, when the F region density normally becomes too low. This early-morning decrease is usually called the pre-sunrise dip, and it is caused by the temperature dipping down just prior to sunrise. Loss of signal is common if the path is being worked near its MUF, but in this case Es holds the signal in with very high signal strengths across the dip. The pre-sunrise dip is usually a propagation problem for a fixed communications circuit. The problem requires at least two frequency changes, one down and another back up, resulting in time lost. If you're not skilled you may lose the other fellow, but Es propagation solves the problem in summer. See last month's, or last year's, May and July *ham radio* magazine DX Forecaster for more on Es.

band-by-band summary

Ten and fifteen meters should give excellent daytime openings to most worldwide locations on both F-region long skip to 2500 miles (4000 km) and sporadic-E short skip to 1200 miles (2000 km) or multiples thereof on many days of the month. Don't expect as much one-hop trans-equatorial DX during disturbed periods this time of year.

Twenty meters will be open to some areas of the world for nearly all hours of the day and night. Sporadic-E propagation will fill in the pre-sunrise dip in usable frequencies during many mornings to make round-the-clock openings possible. The direction of the openings will not be much different than usual, and the openings will be extended in time.

Forty meters will give the best DX during the night from sunset until just after sunrise. Static levels may be high at times. Watch for local storms and operate near Sporadic-E peaks around sunrise and sunset (particularly sunrise, when fewer thunderstorms have built up).

Eighty meters on some nights can have DX openings to areas of interest. Static from thunderstorm activity, long distance and local, may limit working the rare ones when propagation is otherwise right. Coastal stations usually have more favorable propagation geometry under summer conditions for working the rare DX than inland stations. Sporadic-E propagation around sunrise and sunset is good for this band also. Daytime work will be limited to within about 220 miles (360 km).

One-sixty-meter DX activities really require a lot of work this time of year. During hours of darkness between storm-front passages, you may work 1000 miles (1600 km) if your ears hold up. DX takes on a new meaning here. You may want to give it a try.

ham radio

JUNE

WESTERN USA

GMT	PDT	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	5:00	—	20	20	15	15	10	10	—
0100	6:00	—	20	20	15	15	10	10	—
0200	7:00	—	20	20	15	15	10	10	15
0300	8:00	15	20	—	15	20	10	10	15
0400	9:00	15	20	—	15	20	15*	15	15
0500	10:00	15	20	—	15	20	15	15	—
0600	11:00	—	20	—	15	20	15	15	—
0700	12:00	—	—	20	20	20	15	15	—
0800	1:00	20	—	20	20	20	15	15	—
0900	2:00	20	—	—	40	40	15	20	20
1000	3:00	20	—	—	40	40	20	20	20
1100	4:00	20	—	—	—	40	20	20	20
1200	5:00	20	—	—	—	40	20	20	—
1300	6:00	20	20	—	—	—	20	20	—
1400	7:00	20	20	—	—	—	20	20	—
1500	8:00	20	20	20	—	—	40	20	—
1600	9:00	15	20	20	—	—	40	—	—
1700	10:00	15	20	20	—	—	40	—	20
1800	11:00	15	20	15	15	—	20	—	15
1900	12:00	15	20	15	10	—	20	—	15
2000	1:00	—	15	15	10	—	20	15	20
2100	2:00	—	15	15	10	20	15	15	20
2200	3:00	—	15	15	15	20	10	10	20
2300	4:00	—	20	20	15	15	10	10	20

MID USA

GMT	MDT	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN	CDT
0000	6:00	15	20*	15	15	15	10	15	15	7:00
0100	7:00	15	20	20	15	20	10	15	15	8:00
0200	8:00	15	20	20	15	20	15*	15	15	9:00
0300	9:00	15	20	—	15	20	15	15	20	10:00
0400	10:00	20	20	—	15	20	15	15	20	11:00
0500	11:00	20	20	40	20	20	15	15	20	12:00
0600	12:00	20	20	40	20	20	15	20	—	1:00
0700	1:00	—	20	20	20	20	15	20	—	2:00
0800	2:00	—	—	20	20	40	15	20	—	3:00
0900	3:00	—	—	—	40*	40	15	20	—	4:00
1000	4:00	—	—	—	40	40	20	40*	40	5:00
1100	5:00	—	20	—	40	—	20	40	40	6:00
1200	6:00	—	20	—	20	—	20	40	40	7:00
1300	7:00	20	20	20	20	—	40	40	40	8:00
1400	8:00	20	20	20	20	—	40	—	20	9:00
1500	9:00	20	—	20	20	—	—	—	20	10:00
1600	10:00	20	—	15	20	—	—	—	20	11:00
1700	11:00	20	—	15	15	—	—	—	20	12:00
1800	12:00	20	—	15	15	—	—	—	—	1:00
1900	1:00	15	15	15	15	20	15	—	—	2:00
2000	2:00	15	15	15	10	20	10	10	—	3:00
2100	3:00	—	15	15	10	20	10	15*	—	4:00
2200	4:00	—	15	15	10	20	10	15*	15	5:00
2300	5:00	—	15	15	15	15	10	15*	15	6:00

EASTERN USA

GMT	EDT	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE CARIBBEAN S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	8:00	15	20	20	15	20	15	15	20
0100	9:00	15	20	40	15	20	15*	15	20
0200	10:00	20*	20	40	15	20	15	15	20
0300	11:00	20	20	40	20	20	15	15	20
0400	12:00	20	40	—	20	20	15	15	20
0500	1:00	20	40	—	20	20	15	20	20
0600	2:00	—	40	20	20	40	15	20	20
0700	3:00	—	40	20	40*	40	20	40	40
0800	4:00	—	40	20	40	40	20	40	40
0900	5:00	—	20	—	40	40	20	40	40
1000	6:00	—	20	—	40	40	20	40	40
1100	7:00	20	20	—	40	—	40	40	20
1200	8:00	20	15	—	20	—	40	40	20
1300	9:00	20	15	15	15	—	40	40	20
1400	10:00	20	15	15	15	—	40	20	—
1500	11:00	20	20	15	15	—	—	—	—
1600	12:00	20	20	15	15	—	—	—	—
1700	1:00	20	20	15	15	—	—	—	—
1800	2:00	15	15	15	10	20	—	—	20
1900	3:00	15	15	15	10	20	15	—	20
2000	4:00	20	15	15	15*	15	15	—	20
2100	5:00	20	15	15	15	15	15	15	20
2200	6:00	20	15	15	15	20	15	15	15
2300	7:00	20	15	15	15	20	15	15	15

*Look at next **higher** band for possible openings.

(Continued from page 6.)

Our last method of communications is RATT, or RTTY. Teletype is tasked with being the workhorse of battalion-to-higher-headquarters communications. You'll find everything from command instructions to orders for repair parts being transmitted by RATT. In many instances the RATT operators are the busiest of all the platoon members.

The RATT van is a Dodge pickup truck with a mobile shelter in the bed. Power for the radios can come from either a 100-amp generator hooked to the truck's engine or from a towable 5-kW generator. You would figure that you could tow the generator with the truck but you can't. It's too heavy. So you always have to depend on someone else to pull your generator and, as you'd expect, this causes problems. A vertical is used for mobile stations and a dipole when staying in one place. The teletype units are model GGC-3s, so hams familiar with RTTY would be at home with them.

Since RATT is the workhorse, or most important element, in battalion-to-higher-headquarters communications, you have to ensure that it is fully protected from enemy interception. Inside the van there is equipment that will code the RATT signals. And it's policy that whenever the radio is used it will be coded. Enough said about that! Because of this security equipment, you really can't hop in the van, go out in the boonies, and play field day. It's a shame because, for a ham, it would be a nice diversion from the day to day routine.

That's about it for my summer camp. Two weeks spent in the field putting systems in and taking them down. And a lot of time spent hurrying up and waiting. Some things never change. That's for sure! It was an interesting experience and I hope a learning one for all involved. I know I learned quite a bit. I just hope we never have to go to war for me to use that experience.

J. Craig Clark, Jr., N1ACH
assistant publisher

HAM CALENDAR

June

SUNDAY | MON | TUES | WED | THUR | FRI | SATURDAY

W1AW Schedule

October 25, 1981-April 24, 1982 **MTWThFSSn = Days of Week** **Dy = Daily**
W1AW code practice and bulletin transmissions are sent on the following schedule.

EST	Slow Code Practice	MWF 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M.
	Fast Code Practice	MWF 4 P.M., 10 P.M.; TTh 9 A.M.; TThSSn 7 P.M.
	CW Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF 10 A.M.
	RTTY Bulletins	Dy. 6 P.M., 9 P.M., 12 P.M., MTWThF 11 A.M.
	Voice Bulletins	Dy. 9:30 P.M., 12:30 A.M.
CST	Slow Code Practice	MWF. 8 A.M., 6 P.M.; TThSSn. 3 P.M., 9 P.M.
	Fast Code Practice	MWF. 3 P.M., 9 P.M.; TTh: 8 A.M., TThSSn. 6 P.M.
	CW Bulletins	Dy 4 P.M., 7 P.M., 10 P.M., MTWThF 9 A.M.
	RTTY Bulletins	Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF 10 A.M.
	Voice Bulletins	Dy 8:30 P.M., 11:30 P.M.
PST	Slow Code Practice	MWF 6 A.M., 4 P.M., TThSSn 1 P.M., 7 P.M.
	Fast Code Practice	MWF 1 P.M., 7 P.M., TTh: 6 A.M., TThSSn: 4 P.M.
	CW Bulletins	Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF 7 A.M.
	RTTY Bulletins	Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF 8 A.M.
	Voice Bulletins	Dy: 6:30 P.M., 9:30 P.M.

1

2

3

4

OREGON STATE HAM CONVENTION — Seaside Convention Center, Seaside, OR. For information contact Doc McLendon, W7GWC, POB 920, Seaside, OR 97123 — **4-6**.

5

PENNYROYAL ARS ANNUAL JEFFERSON DAVIS QSO PARTY — 1500 to 2400 UTC. Suggested frequencies: 3.940, 7.260, 14.310, 21.410, and 28 610 MHz phone and 3.730 MHz CW — **5**.*

SUPERFEST 4 — by Northern Colorado ARC at the McMillen Bldg., Larimer County Fairgrounds, Loveland, CO. Contact Gene Bellamy, WDØDRM, 3124 West 6th St., Greeley, CO — **5**.

GRAND RAPIDS FESTIVAL SWAP & SHOP — by the Independent Repeater Association at the Kentwood Field House south of 60th St. on Kalamazoo Ave. Contact I.R.A. SWAP, 562-92nd St. SE, Byron Ctr., MI 49315 — **5**

THE NORTH AREA REPEATER ASSOCIATION'S SWAPFEST & EXPO — Minnesota State Fairgrounds, St. Paul. Contact Amateur Fair, POB 30054, St. Paul, MN 55175 — **5**.

PEA PATCH ISLAND MINI EXPEDITION — by Wilmington-area hams using your own call and the Fort Delaware identifier. See Operating Events — **5-6**

THE ARCTIC ARC OF FAIRBANKS HAMFEST — Kiwanis AG Hall, Tanana Valley Fairgrounds. Contact Herb Walls, KL7JLF, POB 1625 Fairbanks, AK 99707 — **5**.

6

11TH ANNUAL MILTON ARC HAMFEST — Allenwood Firemen's Fairgrounds, U.S. Route 15. Contact Jerry Williamson, WA3SXQ, 10 Old Farm Lane, Milton, PA 17847 — **6**.

HUMBOLDT ARC ANNUAL HAMFEST — Bailey Park, N. 22nd Ave., Humboldt, TN. Contact Ed Holmes, W4IGW, 501 N. 18th Ave., Humboldt, TN 38343 — **6**.

CHELSEA SWAP & SHOP — Chelsea Fairgrounds, Chelsea, MI. Contact Bill Altenberndt, 3132 Timberline, Jackson, MI 49201 — **6**.

JERSEY SHORE HAMFEST & ELECTRONIC FLEA MARKET — By The Fort Monmouth ARC and Haverim. Contact Jersey Shore Hamfest, POB 2078, Ocean, NJ 07712 — **6**.

ROME HAM FAMILY DAY — sponsored by the Rome ARC, Beck's Grove, Oswego Road, Rome, NY. Contact Rome Radio Club, POB 721, Rome, NY 13440 — **6**.

MID-ATLANTIC AREA QUALITY HAMFEST — Prince William County Fairgrounds, sponsored by The Ole Virginia Hams ARC of Manassas Contact Jim Lascaris, WA2QEJ, 11053 Camfield Court, Manassas, VA 22110 — **6**.

7

WEST COAST BULLETIN — 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM — **7**

8

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

9

10

11

HARBORFEST-TRICENTENNIAL SPECIAL EVENT STATION — by the Tidewater-area Amateur clubs. The station will operate 24 hours a day 80 through 2 meters CW and SSB. Contact Bill Verebely, KC4YX, 3101 Petre Rd., Chesapeake, VA 23325 — **11-14**.*

12

CENTRAL MICHIGAN AMATEUR REPEATER ASSOCIATION'S 8TH ANNUAL HAMFEST — Valley Plaza Complex off Rt. 10, Midland, MI. Contact Carol Hall, WD8DQG, 4651 Cardinal Dr., Mt. Pleasant, MI 48858 — **12**.

KOOTENAI ARC HAMFEST '82 — Kootenai County Fairgrounds, north of Coeur D'Alene on old Hwy. 95. Contact Avon Anderson (SASE), WB7WBZ, N. 1035 Highland Ct., Post Falls, ID 83854 — **12**.

STATEN ISLAND ARA FLEA MARKET — All Saints Episcopal Church, Staten Island, NY. Contact George Rice, Jr., WA2AMJ — **12**.

STAR SPANGLED BANNER SPECIAL EVENTS STATION — Station WB3KUH will operate from Ft. McHenry, Baltimore, MD. Both SSB and CW will be used on 20, 15, 40, 2, and 6 meters — **12-13**.*

WORLDWIDE SOUTH AMERICA CW CONTEST — **12-13**

ARRL VHF QSO PARTY — **12-13**.

13

15TH ANNUAL GOODYEAR ARC HAMFEST — Goodyear Wingfoot Lake Park, near SR224 and 43 east of Akron. Contact Don W. Rogers (SASE), WA8SXJ, 161 S. Hawkins Ave., Akron, OH 44313 — **13**

HALL OF SCIENCE ARC INDOOR/OUTDOOR HAMFEST — Municipal Parking Lot, 80-25 126th St., Kew Gardens, Queens, NY. Contact KA2DTB — **13**.

MONROE COUNTY RADIO COMMUNICATIONS HAMFEST — at Monroe Community College, Raisinville Rd., Monroe, MI. Contact Fred Lux, WD8ITZ, POB 982, Monroe, MI 48161 — **13**

THE 6-METER CLUB OF CHICAGO'S SILVER ANNIVERSARY HAMFEST — Santa Fe Park, 91st and Wolf Rd., Willow Springs, IL. Contact Val Hellwig, K9ZWV, South 60th Court, Cicero, IL 60650 — **13**.

TRI-STATE ARA 20TH ANNUAL HUNTINGTON HAMFEST — Camden Park off route 60 West. Contact T.A.R.A. Inc., POB 4100, Huntington, WV 25729 — **13**

CHAMPAIGN LOGAN ARC ANNUAL HAMFEST & FLEA MARKET — Logan County Fairgrounds, Bellefontaine, OH. Contact M.A. Griswold, W8JXM, POB 301, Urbana, OH 43078 — **13**

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15

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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17

18

SUMMER SMIRK PARTY — **18-20**

19

RARITAN VALLEY RADIO CLUB'S 11TH ANNUAL HAMFEST & FLEA MARKET — Columbia Park, Dunellen, NJ. Contact Bob, KB2EF — **19**

THIRD ANNUAL YANKEE HAMFEST — Sponsored by the Yankee Radio Club, Oxford County Fairgrounds, Oxford, ME — **19**.

FIFTH ANNUAL TREASURE VALLEY HAMFEST — sponsored by the Voice of Idaho ARC and the Treasure Valley Radio Association. Contact Samuel K. Sower, N7DOV, 1909 Grant St., Caldwell, ID 83605 — **19-20**

CAPE FEAR ARS SPECIAL EVENT STATION — Club Call WB4YZF from the 14th annual National Hollerin' Contest, Spivey's Corner, NC. Operation will be on 7235 MHz between 1300 and 2100 UTC — **19**.*

20

A5 MAGAZINE WORLDWIDE SSTV DX CONTEST — **20-21**

LANCASTER & FAIRFIELD COUNTY ARC ANNUAL LANCASTER HAMFEST — *Fairfield County Fairgrounds, Lancaster, OH. Contact* Box #3, Lancaster, OH 43130 — **20**

LAKE COUNTY ARC 10TH ANNUAL DAD'S DAY HAMFEST — Lake County Fairgrounds, Industrial Arts Bldg., Crown Point, IN. Contact Walley Kozol, KA9FDC, 624 N. Rensselear St., Griffith, IN 46319 — **20**

21

WEST COAST BULLETIN — 9 PM PDT (8 PM PST, 0400 UTC) 3540 KCS A-1 22 WPM — **21**

22

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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TRI-CITY ARC SPECIAL EVENTS DAY — Goodnoe Wind Turbine Site, 10 miles E. of Goldendale, WA — **26-27**.*

ARRL FIELD DAY — **26-27**.

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AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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***SEE COMING EVENTS**

operation upgrade: part 7

In this month's issue, Bob discusses the basics of transmitter design

This article is aimed at helping you with the fundamentals of ham radio. With this information you should understand the subjects on the FCC test questions better. The subjects explained are specifically for Novice, Technician/General, and Advanced class license aspirants. After the fundamentals are presented, in as simple a form as possible, there will be a short series of Extra-class license subject articles.

The first article, or Part 1, in the September, 1981, issue, discussed basic direct current (dc) circuits involving resistors and voltage sources. Part 2 (October) investigated some alternating current (ac) circuits with inductors, capacitors, and resistors. Part 3 (January) took a broad look at active devices such as diodes, transistors, and vacuum tubes. Part 4 (February) went into the basic power supplies and a few simple amplifier circuits. Part 5 (March) developed the theory of oscillators. Part 6 (April) was an overall outline of a variety of amplifier forms including classes of operation. In Part 7 we will put some of the basic theory to work in explaining radiotelegraph (CW or A1) transmitters of various types, and include a little about antennas. This is really the first "radio" article. Prior subjects were used to lay the groundwork, so that you might have a better chance of understanding how "systems" composed of two or more circuits can function. It might be a good idea to go back and thumb through the last few articles so that the terms we used will be fresh in your mind.

a basic transmitter

To communicate on the Amateur bands with some other Amateur down the street, across town, across the country, or across the oceans, you must have: (1) something to generate a radio frequency ac, (2) an antenna to radiate the rf energy into space, (3) some way of controlling the rf ac to make it carry intelligence for you, and (4) a device which will make received rf ac signals audible to you (a receiver).

Let's look at the simplest kind of rf ac generator — an oscillator — that will allow you to actually communicate with someone else. The Hartley oscillator of **fig. 1** should work satisfactorily on the 160, 80, and 40 meter Amateur bands. As a transmitter it may not have much power output, but you might be able to communicate up to 500 miles with it if conditions are right.

When the key is closed the rf power-type bipolar *junction transistor* (BJT) circuit starts oscillating. You can check to see if it is oscillating with a two-turn loop of wire connected across a low power flashlight lamp, shown in the box. When the loop is coupled (held near) to the LC circuit coil, the lamp should glow.

The rf ac developed in the tuned LC circuit is coupled through the 20-pF capacitor to the antenna wire. If the antenna wire is cut to a half-wavelength ($\lambda/2$) to make it resonant at 7 MHz, where $\lambda/2$ *in feet* $= 468/f_{MHz}$ *(66 ft ±)*, or $\lambda/2$ *in meters* $= 142.5/f_{MHz}$ *(20.4 m)*, electrons will oscillate back and forth along the antenna producing 7-MHz electromagnetic fields around the wire, and 7-MHz electrostatic fields from

By Robert L. Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

end to end. These fields expand and radiate out into the space surrounding the antenna. This forms the radio wave that travels outward with a maximum strength at right angles to a $\lambda/2$ antenna, and minimum strength in the direction of the wire. The velocity of radio wave travel in a vacuum is roughly 186,000 mi/s, or 300,000,000 m/s.

If the key is closed and opened to produce Morse code letters, it is possible to communicate with other Amateurs. There are, however, some difficulties with this simple circuit. For one thing, any change in the emitter-collector voltage will change the frequency of oscillation a little. The frequency is also affected by the voltage built up across the 200-pF base-to-LC coupling capacitor. As a result, when the key is closed the emitter-collector voltage (E_C) rises to 12 volts as soon as the 0.01-μF capacitor between collector and ground charges to this value. The 200-pF capacitor must also rise to its operating voltage. Until these final voltages are attained the frequency will continually be changing. It may be only a few hundred hertz of frequency variation and may occur in a few milliseconds, but it is usually noticeable to the listener as a rising or falling chirping tone at the make and break of each stroke. We say the signal sounds chirpy. This is not good.

[Before we go any further, it's important to say that you may build such a QRP (low power) transmitter, but without a license you cannot legally use it if you connect it to an antenna. You must have at least a Novice or Technician license before you can operate it on the Novice bands (3700-3750 kHz for the 80-meter band, and 7100-7150 kHz on the 40-meter band). If you have a General or higher class license you may use it to transmit code on the 160-meter band (1800-2000 kHz), or the 80-meter band (3525-3775 and 3800-4000 kHz), or the 40-meter band (7025-7300 kHz). See FCC Rules and Regulations, Part 97 for the complete list of Amateur frequencies.]

Another unsatisfactory feature about a simple transmitter like this is the frequency instability it will have. For example, if the power supply (battery) changes voltage when under a load (key down) the frequency will change. If you put your hand near the LC circuit you will be substituting the dielectric coefficient of your hand for that of the air surrounding the LC circuit. As a result the overall capacitance of this circuit increases and the frequency will decrease. If the antenna swings in the wind its capacitance to ground will change and this will be felt by the LC circuit as a change in capacitance across it, resulting in a swinging of the transmitting frequency. As the components (BJT, capacitors, coil, resistors) warm or cool, their values may change slightly, usually causing a slow drift of frequency.

All in all, it doesn't seem like a worthwhile rig to be using. But by employing mica or air dielectric capacitors, a heavy-duty battery or a voltage-regulated power supply, by using a good heatsink on the transistor, by shielding the oscillator (building it inside a metal box, dashed lines), by grounding the shield, and by stretching and holding the antenna tight, such a little transmitter can be a lot of fun to play with. If you use a crystal oscillator instead of the Hartley circuit, it will usually result in a stable output, but on only the one frequency to which the crystal has been ground.

Although an oscillator can be made that will operate with the maximum of one kilowatt (1 kW) dc power input permitted for Amateur transmitters, increasing the power output of an oscillator above a few watts will usually result in very poor frequency stability characteristics and bad key clicks.

Briefly, if it takes 100 cycles of the 7-MHz rf ac being generated to build up to the maximum carrier ac level after the key is pressed, this represents the first quarter cycle of a modulating wave having a frequency of about 4 × 100, or 7,000,000/400, or 17.5 kHz. As a result, when keying you would not only be transmitting energy at the 7-MHz carrier frequency, but also "sideband" energy out 17.5 kHz on both sides of the carrier. These broad-bandwidth spurious signals will sound like clicks to anyone having a receiver tuned to anywhere within at least 17.5 kHz of your carrier frequency. Furthermore, when the key opens, the carrier amplitude drops very rapidly, causing even higher frequency sidebands and key clicks that extend out even further.

A method of reducing key clicks is to slow the buildup and the drop-off of the carrier ac. This can be accomplished by using a key-click filter: an inductor (which opposes any change in current) in series with the key, and a capacitor (which opposes any change in voltage) across the key, as shown below the key symbol in **fig. 1.** The resistor reduces the discharge current when the key closes across the charged capacitor, preventing pitting of the key contacts. Unfortunately, slowing the rise and fall of the carrier strength of an oscillator also accentuates the chirping. Transmitters up to perhaps 10 watts output will not usually produce bothersome key clicks. Above this power level they may begin to give trouble unless some improved form of keying is used.

an MOPA transmitter

The next step in producing a more desirable transmitter is to add an amplifier after the oscillator. This makes up a system called a master-oscillator-power-amplifier, or an MOPA. The MOPA can deliver much more power to the antenna and still be relatively stable.

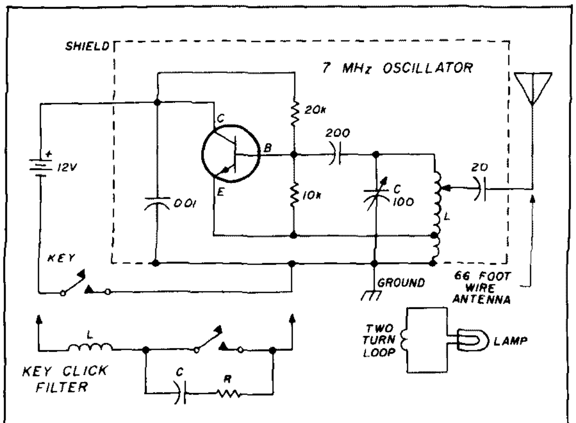


fig. 1. Simple self-excited oscillator 7 MHz band CW transmitter.

With an MOPA, in most cases the oscillator is allowed to operate all of the time that the transmitter is turned on. Keying is usually accomplished by switching the power amplifier on and off with a telegraph key, as in **fig. 2**, or more likely, with a keying relay, shown dashed. This diagram illustrates a possible MOPA that could be used to transmit CW signals. The term CW means continuous-amplitude waves, and is used to indicate code transmissions. In the "good old days" of radio, spark transmitters were used to send code. But spark oscillators generated rf ac in 120 to 1000 wave trains (dying out rf ac bursts) per second. Because of the nonsinusoidal damped characteristics of these rf pulses the emitted wave was very broad. When vacuum tubes (VTs) were developed they produced constant amplitude (strength) carriers. When not carrying intelligence (on-off code, or speech "modulation") a carrier has essentially zero bandwidth and is termed AØ (A-zero) by the FCC. When broken up into code signals the emission is called A1. The A indicates a carrier having its amplitude varied, and the 1 indicates that intelligence is being conveyed by using some kind of a code. The bandwidth of such an emission will be broader the faster the code speed used.

The MOPA circuit is shown in both block diagram form and as a schematic diagram. In both cases there is a transmit-receive (TR) switch to throw the antenna from receiver to transmitter when it is desired to change from receive to transmit or back.

Do you recognize the oscillator to be a JFET Hartley? It is shown capacitively coupled to the grid of a triode VT, which in turn is inductively coupled to a tuned antenna circuit.

Although shown as a JFET, the active device in the oscillator might just as well be a BJT or a VT. This stage determines the transmitting frequency of the transmitter. The output power of the oscillator might be about 1 watt of rf ac. With active devices made for higher power, the oscillator output may produce several watts of rf ac drive to the input of the amplifier. Usually, the less the power output of an oscillator the better its stability (and the less frequency drift, chirp, etc.).

The amplifier is shown as a "neutralized" VT triode. It might have been shown as a VMOS or other power FET, a power BJT, or a beam power tetrode. The FETs would have essentially the same circuitry as the triode VT, but the BJTs, being a lower impedance type device, would require some variations in the circuit impedances (tapped down coils, greater capacitance values, etc.). As explained in Part 5, the capacitance which exists between plate and grid of a VT triode (drain-to-gate of an FET) can feed back ac energy and cause an amplifier to oscillate rather than amplify. To prevent this, the electrical center of the output tuned circuit can be tapped and bypassed to

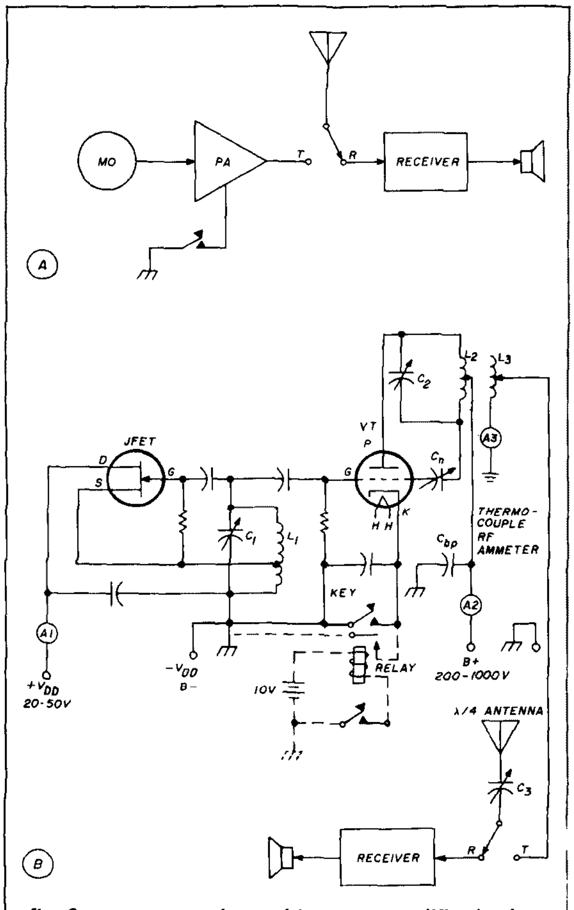


fig. 2. MOPA transmitter with power amplifier keying, *A* in block form, and *B* in schematic form showing relay keying dashed.

ground. Now the plate current pulses coming down through the top half of L_2 start LC circuit flywheel oscillations. The rf ac is developed at the frequency of the pulses, which are at the frequency of the oscillator's ac that is driving the grid or input circuit of the PA. Since the center of the LC circuit is at ground potential due to bypass capacitor C_{bp}, when the top of the coil is ac positive the bottom of the coil will be equally ac negative. Any feedback from plate to grid due to interelectrode capacitance can be completely cancelled, provided the neutralizing capacitor C_n is set to whatever the value of the P-G feedback capacitance happens to be.

Although we say the feedback capacitance is the interelectrode capacitance of the active device, actually it is somewhat more because of nearness of connecting wires and components external to the active device. If the P-G capacitance is 5 pF, there might also be 3 pF of external capacitance, requiring a setting of 8 pF for C_n. For this reason C_n is almost always a small variable capacitor.

The keying is accomplished by closing and opening the PA cathode-to-ground connection. Can you see that if you happened to get your fingers across the open key that you would be between ground (B −) and high voltage (B +) through the conductance of the triode? This will really jar your teethl So, whenever there is more than 100 or possibly 200 volts involved, a keying relay should be used, shown dashed. The low voltage of the keying circuit will cause no physical discomfort, since *with dry hands* you will normally feel no current shock with potentials up to perhaps 40 to 50 volts. (With really good electrical contact to your two hands 12 to 15 volts might kill you!)

If you can imagine the relay as having two sets of arms and contacts (the second connected to the antenna), can you see that it would be possible, by pushing the key down, to not only close the cathode lead, but also to shift the antenna's relay arm from receive to transmit at the same time? When your key is up you would be able to hear incoming signals because the antenna would then be connected to the receiver. When the key is down the transmitter is coupled to the antenna and all you would hear is your own transmitter. This is known as "full break-in" (or QSK, meaning, I can hear you between my dots or dashes), which is the only way to go on CW. The other Amateur can stop you by merely pushing his or her key down for a second and you will hear the signal and stop transmitting. If other Amateurs start tuning up on your frequency while you are sending you will know it and can move away from the QRM (interference).

To tune an MOPA transmitter like this you would go through a series of steps somewhat as follows:

1. Turn on the oscillator power supply (not the PA supply) and adjust C_1 until you hear your signal (usually a whistle) on the spot on the band where you want to operate.

2. Listen to your signal on the receiver and adjust C_2 until you obtain a maximum received signal of the oscillator feeding or leaking through the amplifier stage.

3. Rotate the neutralizing capacitor to minimum received signal, which indicates proper amplifier neutralization.

4. Turn on the PA power supply, and, as soon as you press the key, adjust C_2 for parallel resonance, shown by a minimum plate current on A_2. (The oscillator meter A_1 should change very little at any time if the amplifier is neutralized.)

5. With this quarter-wavelength *antenna* (33 ft for 7 MHz) adjust C_3 to antenna series resonance, shown by a maximum current indication on the rf ammeter A_3. You will find that this will also produce an increase in the A_2 reading because now the amplifier is being more heavily loaded. Under a load the PA LC circuit Q goes down, and it presents a lower impedance to the VT, resulting in greater plate current (I_p).

Always be sure to listen to the frequency on which you plan to work before you transmit anything. Even if the frequency is clear do not hold your key down any longer than about five seconds, and then immediately send TEST DE followed by your call sign. If the band is busy or your testing is going to take a protracted time, couple your PA to a dummy load instead of the antenna. Tune up on low power (low B +). A 100-watt lamp has a cold resistance of about 20 ohms and a hot resistance of about 144 ohms. With a few-turn loop across it, it can be used as a dummy load for transmitters that emit 10 to 100 watts of rf. Keep in mind that even with a dummy load your signal may be carrying quite a few miles. If you are using an antenna that requires no tuning, it will usually require a 50-ohm or a 70-ohm dummy load. Actually, a 2:1 to 3:1 impedance mismatch will not matter too much for a dummy load (50 ohms to 100 ohms represents a 2:1 mismatch and a standing wave ratio, or SWR, of 2:1. This will be discussed more in later articles.)

Actually, the antenna ammeter is not necessary except that it can be used to tell you your approximate power output by computing power from $P = I^2R$. You can use 40 ohms for the impedance at ground for a quarter-wavelength antenna.

The amount or degree of coupling to the antenna can be adjusted by changing the number of turns you use on the antenna coil. With only one turn you will

couple very little energy to the antenna. As you move the tap (arrow) up the coil you will be able to couple more energy out of the L_2C_2 tank circuit, but you will also be increasing the length of the antenna circuit and its inductance. We say you are making the antenna more inductive (increasing its X_L value). To compensate for this you will have to decrease the antenna capacitor C_3 a little (increasing its X_C) to bring the antenna circuit back into resonance. How much coupling is required is determined by how much plate (drain, collector) current you want to use. If the tube manual says use 100 mA (milliamperes) and you find that at L_2C_2 resonance and I_p minimum you read only 80 mA on meter A_2, you can safely increase coupling. If your I_p value is 110 mA when the rig is tuned you are overcoupled and should back off on the coupling or you may shorten the life of the tube needlessly. The difference between any increase in power for those extra 10 mA will not be noticeable to the Amateur at the receiving end.

Another method of varying the coupling is to physically move the antenna coil closer or farther away from the PA tank circuit. If you are very clever you can arrange the antenna coil so that it rotates inside, or at the end, of the LC tank coil. When the antenna coil is in line with the PA coil the coupling will be at a maximum. When turned 90°, the coupling will drop to zero. Such an arrangement is known as a variocoupler, but is rarely seen anymore.

improving the MOPA

While the MOPA is a great improvement *over a* simple oscillator as a transmitter, it has some drawbacks. For one thing, unless the neutralization is perfect and the oscillator and the PA are completely shielded, there will be some leak-through of the oscillator signal when the PA key contacts are open. Even with the best neutralization and shielding there may be enough oscillator leak-through signal to block out reception of weak signals on the receiver. This "backwave" can be eliminated by keying the oscillator, but then chirps and instabilities become a problem again. When neutralization is not complete on some other Amateur's transmitter, you may sometimes hear the backwave signal if relay type break-in keying is not being used at that station. The backwave is transmitted in such a case because the antenna switch is connected to the transmitter as long as that station is transmitting.

The addition of a buffer amplifier between the oscillator and the PA improves things greatly. Now the oscillator is further isolated from the PA and the antenna. A buffer amplifier might be a neutralized triode tube, FET, or BJT stage, or it may be a tetrode or pentode tube amplifier which may need no neutralization. Since the buffer is an amplifier, it will allow the oscillator to operate *at a lower power* output level, which helps frequency stability. It may also drive the PA harder, which means greater output possibilities for the PA. If the buffer is keyed instead of the PA, the backwave will usually be reduced to insignificance if all stages are properly neutralized and shielded.

If the buffer amplifier is used as a frequency multiplier (doubler, tripler, etc.) frequency stability and backwave difficulties will be improved still more. The diagram of **fig. 3** illustrates a doubler stage link coupled to a tuned LC tank of the next stage's input circuit. If a 3.5 MHz oscillator's rf ac is fed to the gate of the JFET, while the gate is driven positive, as indicated on C_c, the right plate of this capacitor picks up electrons from the JFET's source. When the rf ac alternates it drives the electrons away from the right-hand plate and they travel down the biasing resistor R. Since electrons always move from negative to positive, the top of R must be more negative than the source. The bias voltage developed across R can be great enough to bias the JFET into class C operation. This means that the drain current pulses flowing down through the LC circuit are far less than 180° in width, usually more like 100° to 120° (considering 360° as the complete rf ac cycle). With narrow pulses there is a relatively long zero-current period of time in between pulses. As a result, if the LC circuit is tuned to resonate at 7 MHz (twice 3.5 MHz), the 3.5 MHz pulses will drive down through the coil to $+V_{DD}$ and then the JFET waits while the LC circuit oscillates (flywheel *effect*) for *two* cycles of 7 MHz ac before another pulse arrives to start the next oscillations. The stage is operating as a frequency doubler. If the value of R is increased (from about 50 kilohms to perhaps 75 kilohms) the bias voltage will increase and the drain pulses will be still narrower, allowing more rest time for the JFET. There should now be time for the LC circuit to oscillate three times before the next pulse arrives. In this case the frequency multiplier is called a tripler. The rf ac power output from a doubler is roughly half what the stage would produce as a straight-through amplifier. It puts out about one-third as much when operating as a tripler. Since the input and output circuits are not resonant to the same frequency, no neutralization is required in frequency multipliers.

As might be expected, any output from a frequency *multiplier will be rich* in harmonics. One method of reducing unwanted higher harmonic output signals is to use tuned circuits at the desired operating frequency. The link coupling shown in **fig. 3** is one method of discriminating against the transmission of higher-frequency harmonics. Link coupling is actually a step-down tuned transformer coupled to a step-

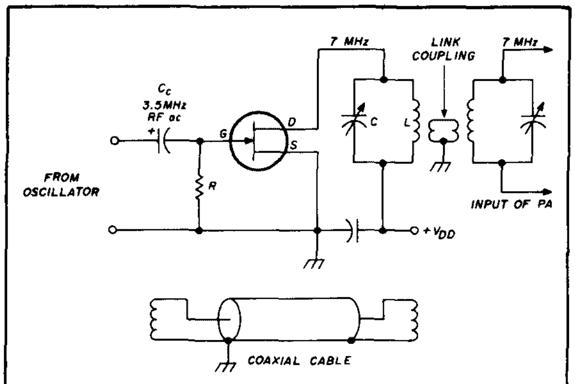


fig. 3. A frequency multiplier stage with link coupling to the next amplifier stage.

up tuned transformer (the number of link turns is not too important as long as both are similar). Link coupling is also advantageous to transfer rf ac from one place to another with minimum losses. The links can also be interconnected by coaxial line with the outer braid grounded, as indicated in **fig. 3**. Usually any form of inductive coupling is superior to capacitive coupling in preventing transmission of unwanted higher harmonic frequencies.

By using a multiplier between the oscillator and the PA, and keying the multiplier, almost all leak-through or backwave will be eliminated.

a heterodyne CW transmitter

Most commercially constructed Amateur transmitters today utilize the heterodyning of two frequencies to obtain a desired third frequency, which is then transmitted. The terms heterodyning, mixing, and beating all mean essentially the same thing. They mean that if one frequency is mixed with another in a nonlinear device (diode, triode type device, etc.) the output will be basically four frequencies: (1) the first frequency, (2) the second frequency, (3) the *sum* of the two frequencies, and (4) the *difference* of the two frequencies. A basic heterodyne CW transmitter is shown in semi-block form in **fig. 4**. The two frequencies to be heterodyned are developed by a 5-MHz variable frequency oscillator (VFO) and a 12-MHz crystal (XTAL) oscillator. Both of these frequencies are fed to the mixer BJT. In the collector circuit will appear the 5 MHz, the 12 MHz, a 17 MHz (sum), and a 7 MHz (difference) frequency. Since only one of these frequencies (7 MHz) is in any of the Amateur bands, L_1C_1 is tuned to that frequency. With both L_1C_1 and L_2C_2 tuned to 7 MHz they discriminate against transmission of all of the other frequencies. As a result, only the 7 MHz signal is amplified by the BJT PA.

Note that the buffer amplifier between the crystal oscillator and the mixer is being keyed. When the key is up there is no 12 MHz signal to be mixed, so there is no 7 MHz output. Inasmuch as there is no 7 MHz being generated anywhere, with the key up there can be no backwave at all. When the buffer is keyed there should be no chirping or frequency instabilities, and (one hopes) no key clicks. Both oscillators are running all of the time, so there is no warm-up frequency drifting after the transmitter has been turned on for a few minutes. It might be noted, however, that if the equipment is not shielded and grounded there might be some radiation of the 5-MHz variable oscillator signal at all times, and some 12 MHz output particularly when the key is down. So shielding is important in all transmitters. In this case we are keying a 12-MHz signal and changing or "translating" it to 7 MHz. We will find translation of frequencies in many radio systems. It is the result of heterodyning.

In the interests of simplicity we have not included any buffer or driver amplifiers between the mixer and the PA. The BJT amplifier shown is worthy of some further explanation. Notice that there is no bias in the

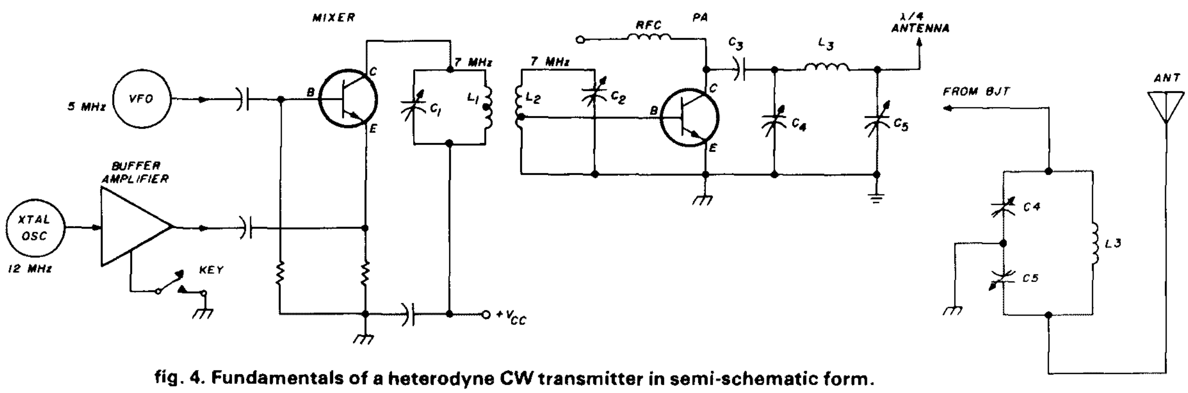


fig. 4. Fundamentals of a heterodyne CW transmitter in semi-schematic form.

base-emitter circuit. The reason for this is that with no forward bias there can be no collector current (I_C) flowing and no output from the stage. It requires about 0.6 volt of forward bias before I_C starts to flow in a silicon type BJT. So BJT stages with no bias are automatically in class C. This can be good in CW transmitters but may be a disadvantage in SSB transmitters. It is important that the voltage driving the base not be so high that so much I_C and I_B flow that the junctions of the BJT melt. A resistor in series with the base may help to protect these junctions, or protective diodes can be used to limit the base driving voltages. Be very careful how hard you drive a BJT. Start with minimum coupling and sneak up to the desired value in small steps.

Note the output tuned circuit in the PA stage. It is coupled directly to a quarter-wave ($\lambda/4$) length antenna wire, which should have an impedance at its base (coupling point) of about 37 ohms. Therefore the part of the tuned circuit feeding it should also have a 37-ohm impedance. The output LC circuit has been redrawn to the right of the PA. Can you see that the PA LC circuit consists of C_4 and C_5 in series across L_3? The values of these components must be chosen so that at resonance the impedance seen by the antenna is 37 ohms across C_5 and that seen by the BJT across C_4 might be perhaps a little more than this value to match a somewhat higher BJT output impedance. As a result, C_5 will need a somewhat higher capacitance value (lower X_C) than C_4 will have. The coil must have the correct inductance to produce resonance at 7 MHz when the two capacitors are set to their correct values. In some equipment C_5 will be a fixed capacitor, while C_4 is variable to tune the circuit to resonance. Capacitor C_5 in many circuits is also variable and functions as a degree-of-coupling control. The greater its capacitance the lower the coupling coefficient to the antenna. For higher frequency bands the L and C values will be proportionally smaller.

The radio frequency choke coil (RFC) has a high impedance to all Amateur bands and therefore develops high 7-MHz ac voltage drops across it when 7-MHz I_C pulses flow through it. These voltages are coupled to the LC circuit by coupling capacitor C_3. This is called a shunt-fed amplifier circuit because no I_C flows through the tuned circuit inductor. Because of its configuration a circuit of this type is known as a pi-network (π-network) tuned circuit.

Note that an earth ground symbol is shown at the base of C_5 which completes the quarter-wave (or $3\lambda/4$) antenna to earth ground to make it resonate properly. This same line is also shown as being at chassis (and metal shielding cabinet) ground.

Can you see that if the 5-MHz variable oscillator is changed to 4.9 MHz the difference signal would then be 12 minus 4.9, or 7.1 MHz? If changed to 4.7 MHz the output would be 12 minus 4.7, or 7.3 MHz. So, if the variable oscillator is tunable from 5 MHz to 4.7 MHz, the resulting output heterodyne signal will cover all of the frequencies in the 40-meter Amateur band (7.0 to 7.3 MHz). If the 12-MHz crystal is changed to an 8.5 MHz crystal (assuming a broadly tuned buffer) the difference signal between 5 MHz and 8.5 MHz will be 3.5 MHz, which is in the 80-meter ham band (3.5-4 MHz). If the crystal is changed to a 17-MHz crystal the difference frequency is 14 MHz and is in the 20-meter ham band (14-14.35 MHz). It is necessary only to switch in different crystals (and amplifier tuned circuits) to change bands in this type of transmitter. Tuning across all bands is accomplished by varying only the frequency of the VFO stage.

The circuit described will work nicely for normal CW (A1), for narrow-band fm (F3) voice communications, and for frequency-shift keying (F1) using any of the various codes such as Morse (CW) Baudot (RTTY), and ASCII (computer). The circuit can also be used for amplitude voice modulation if the PA is the stage to which modulation is applied. To use single-sideband (SSB) amplitude modulation the PA bias must be changed to class A or AB by forward biasing the BJT base. Although modulation is dealt with in later articles, we might point out that if the power supply feeding the PA (or any amplifier stage) is not adequately filtered, its dc voltage output will have a ripple or variation in it. As a result the output signal of the transmitter will be alternately stronger and weaker at the frequency of the ripple. We say the carrier is "modulated" in strength by the ripple. To a receiver the signal would have an audible tone component equivalent to the ripple frequency. Assuming 60-Hz ac as the power source, the ripple frequency would be 60 Hz if the power supply is half-wave rectified, and 120 Hz if it is full-wave rectified. The resulting low-frequency tones produced in the receiver is known as a hum, or as hum modulation. This is an amplitude modulation since it varies the strength of the signal being radiated. If the oscillator power supply has ripple in it, the result may be both an amplitude modulation plus a slight variation of frequency of the oscillator, which would be known as frequency modulation.

an electronic TR switch

When full break-in CW is desired, but without the use of the electromechanical relay mentioned previously, an electronic TR switch can be used. There are a variety of such devices. A simple form is shown in **fig. 5**. These circuits have no connection with the keying circuit at all. The transmitter can be oscillator, buffer, or PA keyed. The antenna input for the re-

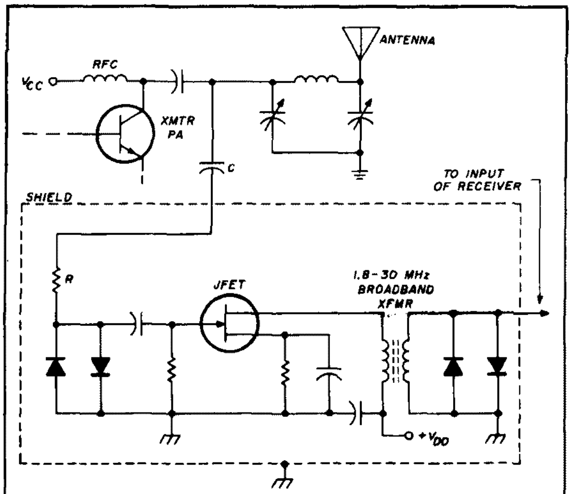


fig. 5. Electronic TR switch feeds received signals to a receiver from a transmitter output LC circuit when PA is not on.

ceiver is taken from the output tuned circuit of the transmitter stage. The TR switch has essentially no effect on the transmission of energy from the transmitter into the antenna. However, it does allow the receiver to be fed received signals from the antenna when the key is up. While the key is down the signal fed to the TR switch would be overwhelming for the receiver's input except for the limiting of this rf by the TR switch circuitry. With the key down, a relatively high-amplitude signal is fed from the π-network tuned circuit to the input of the TR switch. If the two input diodes are silicon types, the maximum rf ac voltage that can be developed across them will be limited to 0.6 volt (0.3 volt for germanium diodes). This limited signal voltage is amplified and fed through the broadband (1.8-30 MHz) transformer (XFMR), is limited again by the two output diodes and is fed to the receiver as an rf ac signal of no more than 0.6 (or 0.3) peak volts, which will not damage any normal receiver.

With the key up the PA has no power output. Now received signals in the antenna at the resonant frequency of the π-network LC circuit are fed to the TR switch. These will usually be in the micro- or low-millivolt range. They will be fed through C and R to the input diodes. Although there is some loss of signal because of the series resistor R, the JFET amplifier can more than make up for that and feed a relatively strong received signal to the receiver. Because almost all received signal voltages developed in an antenna will be well below the 0.6-volt barrier voltage of the diodes, the diodes have no effect on such signals, although it is possible that they might limit extremely strong local signals. With a well designed TR switch, full break-in operation is possible with any CW transmitter. However, PA stages using VTs must be biased to class C to prevent the receiver (discussed next month) from picking up "white noise" generated by random electron movements in resistors or between elements in active devices.

FCC test topics

The following Novice test topics are discussed in this article, but should be understood by Technician/General and Advanced applicants also:

- emission type A1
- block diagram of stages in a simple telegraphy transmitter
- superimposed hum, cause and cure
- backwave, cause and cure
- key clicks, cause and cure
- chirp, cause and cure
- vacuum tube applications, symbols
- quartz crystal applications
- undesirable harmonic output
- functional layout of a Novice CW transmitter including antenna switching, antenna, and telegraph key.
- transmitter tune-up procedure

The following Technician/General class FCC test topics are discussed in this article, but should be understood by Advanced class license applicants also:

- emission types AØ, F1, F3
- neutralizing final amplifiers
- sidebands
- physical dimensions of antennas
- transformer applications and symbols
- antenna tuning
- use of a nonradiating load or dummy antenna
- full break-in telegraphy
- electronic TR switch
- frequency translation, mixing, multiplication
- modulation, amplitude, frequency
- bandwidth

The following Advanced class FCC license test topics are discussed in this article, but should be understood by Extra class license applicants also:

- electromagnetic radiation
- transmitter final amplifiers
- oscillators, applications, stability
- rf amplifier stages

For additional information on these subjects you can refer to *Electronic Communication*, or to *Amateur Radio Theory And Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore.

ham radio

what about the big-amplifier power supply?

Design tips for this all-important piece of equipment

You are planning the construction of that ultimate high-power amplifier with the big triodes. Researching the library and ham journals has been completed, but you are still unsure of the power supply. Almost all articles on the subject skim through the power supply, treating it as a necessary evil.

If you think about it, you'll realize that the power supply is far and away the most important part of the amplifier. The initial problems found in a newly completed amplifier generally point to power supply deficiencies. This article will not only provide you with the complete circuit of the supply but will guide you through the complete relay sequence and point out pitfalls, alternatives, and consequences so that you, on your own, can build the supply you need.

You've already decided upon the plate voltage to be used in your amplifier and have procured that ugly thing known as a power transformer. It weighs between 35 pounds (if you're lucky) and 110 pounds (16-50 kg). The transformer is probably an irritating subject by now, as it won't fit properly into any plans you have formulated. But one way or another you will manage to get it into the supply.

Caution! This type of power supply contains voltages that can cause death or paralysis. Handle with all precautions, respect, and care. **Editor**

The purpose of this article is not to tell you how to determine the secondary voltage you'll need for a particular dc loaded voltage, as it never comes out correct anyway. One of the reasons for this is that the transformer used by most hams has a secondary resistance that's too high and a current-carrying capacity that's too low — but is good enough for Amateur intermittent service. The no-load to full-load voltage may vary from 200 to 1500 volts. For more information on this subject, I would suggest you read the Intermittent Voice Service (IVS) rating section in the power supply chapter of the *Radio Handbook* by Bill Orr, W6SAI.

input requirements

Let's now proceed with what's vital for a reliable power supply. The very first consideration is a negative one. Don't even think of using a supply with 120-volt line power. Primary power of 240 volts is a must, and a 25-amp circuit breaker should be incorporated into the power supply chassis or cabinet. I assume that there's a 30-amp unit in your main breaker box. Other fuses in the power supply are a 2-amp fuse for 120-volt line overload protection, and a 1½ amp fuse, generally used in the rf cathode circuit in the rf deck.

Referring to the schematic of **fig. 1**, you will note a full-wave bridge circuit. This may not be consistent with the secondary voltage of your transformer. You

By Robert E. Bloom, W6YUY, 8622 Rubio Avenue, Sepulveda, California 91343

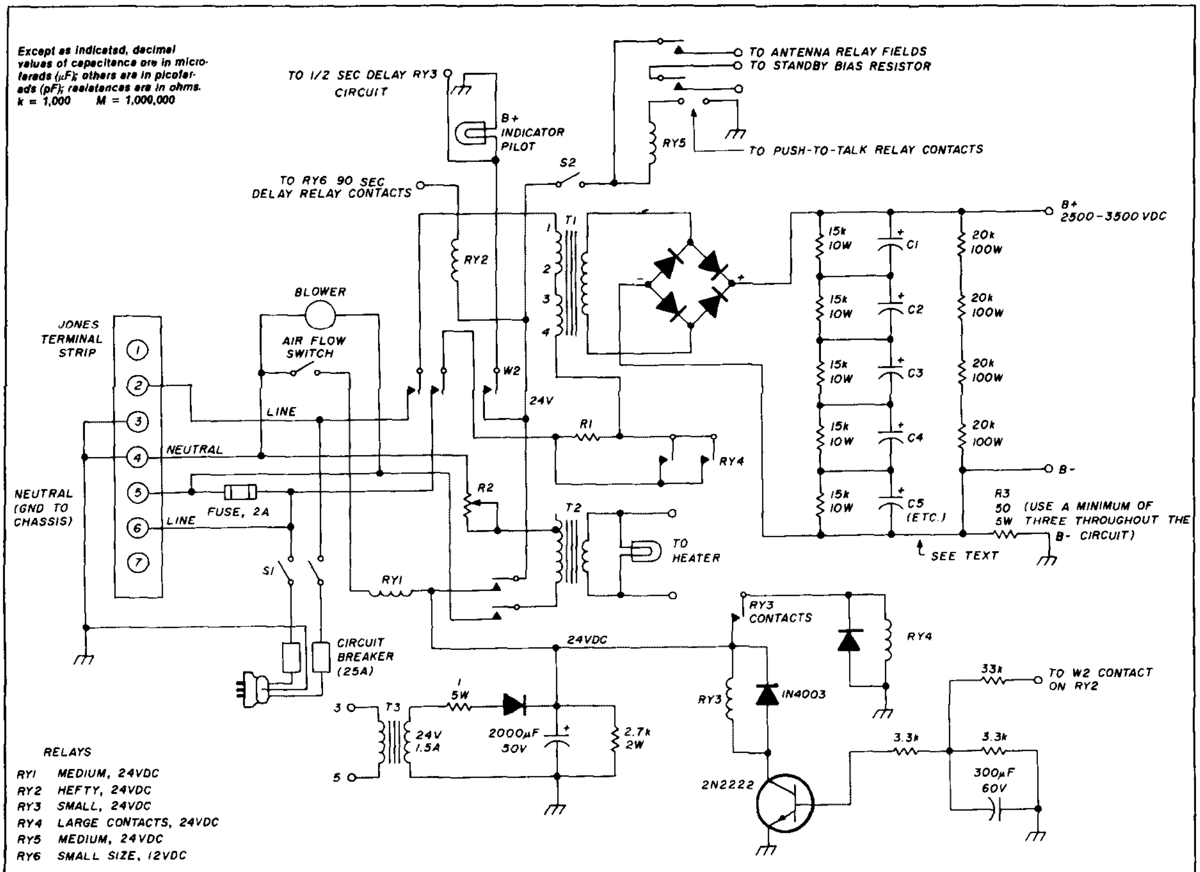


fig. 1. Schematic diagram of the big-amplifier supply. Circuit features safety precautions and relay switching logic for complete power-amplifier control. The rectifier circuit is a commercially available bridge rather than a diode string. Resistor R1 is a heater element, which protects the power-transformer from inrush current surges during turn-on. Relay timing and event sequences are discussed in the text.

may need a voltage doubler circuit, or perhaps the secondary ac voltage is high enough for just a simple full-wave circuit. At any rate, remember that a 2-kilovolt-ampere RMS transformer will put out only 2 kilowatts of power RMS. The transformer may have a tapped primary to reduce the power-supply voltage for tune up. Remember that the rf-load impedance changes downward when the supply is switched back to the higher voltage. The amplifier's circuit *Q* now must be brought back up, requiring an increase in plate as well as load capacitance.

If your amplifier uses a ceramic-type tube or tubes, you'll be using a squirrel-cage blower for cooling. Should the blower fail during operation, the chances are that the amplifier tube will too, and that's an expensive failure. Thus an air-flow switch is a must. If the blower fails, the air-flow switch shuts down both the plate and heater voltages, protecting your expensive tube from seal fracture.

filter system

The filter circuit is the next important item in the supply. A swinging choke is nice to have, as it provides better voltage regulation and also provides a means for obtaining an increase in output voltage (by shorting out the choke). However the choke is large and takes up a lot of room, so I'd eliminate it. The filter capacitors can be the high-voltage oil type (they are expensive). Series capacitors are often used. These are most always high-capacitance electrolytic types with a working voltage of 450 volts and a surge voltage rating of 500 volts. The total capacitance of the series string is equal to the value of one capacitor divided by the total number used, assuming all are of the same capacitance rating. The voltage rating of the string is the working voltage of one unit multiplied by the total number in the string.

The total voltage should be at least equal to the

peak voltage of the supply (1.4 times the RMS value) plus a 10 percent safety factor. Each capacitor should be shunted with a 10 to 20 kilohm, 10-watt resistor — approximately 25 kilohms to 50 kilohms *total* per thousand volts of supply. These resistors are important: they equally divide the supply voltage across each capacitor, thus preventing any one from exceeding its rating. An additional high-wattage bleeder resistor should be used to bleed the voltage from the capacitors. This resistor should draw about 50 mA of bleeder current. By rule of thumb, use 100-watt, 20 kilohms for each 1000 volts of supply voltage.

rectifiers

Most articles in the Amateur handbooks show a string of 1000-volt, 3-ampere (30-amperes surge) rated diodes in series for the high-voltage rectifiers. One determines the peak ac voltage plus a safety factor in each branch of the circuit. These articles suggest a series string of enough diodes to satisfy the voltage requirement. A 250k, 1/2-watt resistor and a 0.01-μF, 1000-volt or higher rating ceramic capacitor are placed across each diode to make up a rectifier stack. The resistors divide the voltage between the diodes, while the capacitor suppresses any spikes or transients.

I've seen this arrangement work satisfactorily in medium-size supplies, but in big supplies I've seen the diodes disintegrate despite the quantity used. I recommend purchasing a 10,000-volt, 100-ampere surge commercial stick rectifier. It is so much neater, takes up less space, probably costs the same and one doesn't have to worry. I believe a double bridge stick runs about $35.00 (possibly available at Henry Radio*). This is inexpensive when you consider what you've already spent on the amplifier.

inrush current

When power is first applied to the supply, the rectified voltage out of the diodes looks into the filter capacitor bank, which at this first instant, is a short circuit. The impedance of the capacitors increases as they take on a charge. The current surge through the rectifiers at the instant of turn-on may well exceed 50 amperes or more. However, with a series string of 3-ampere diodes with a surge rating of only 30 amperes, there is no question as to why things explode. There have been several instances that I know of where the diodes did not blow up; however, the power-line fuse did. The comments heard go something like this: "This has happened before, but when I change the fuse or reset the breaker, the problem goes away." Until, of course, it happens again.

*Henry Radio, 2050 S. Bundy Drive, Los Angeles, California 90025, (213) 820-1234.

Whether or not the fuse blows depends upon the line voltage phase at the instant power is applied to the transformer. If you catch this at the top of the power cycle, you transform the maximum peak current and then — instant disaster.

There are a number of circuits that will prevent this from happening. The one I prefer is to place a heating element in series with one side of the high-voltage transformer primary. This added resistance absorbs inrush current. This resistor in my supply (R1 in **fig.1**) is shorted out by the relay contact of RY4 about a half second after RY2 activates. The timing of this half second is controlled by the time constants of the resistors and capacitor in the base circuit of the 2N2222 transistor. I believe these resistor elements can be purchased at most electrical supply houses and are available in both 120- and 240-volt versions. A very heavy duty relay (RY2) should be used in the high-voltage transformer primary circuit. A third set of contacts on this relay is used to furnish 24 volts to other parts of the circuit at the proper time.

In addition to the one-half-second delay relay used to short out R1, there is a requirement for a second delay circuit of 90 seconds. This 90-second delay allows the rf amplifier tube heater to attain the proper temperature before B+ is applied.

Most power supplies I have seen use an Amperex time-delay relay that has the physical configuration of a vacuum tube. The circuit I use has an accurate electronic time delay, which can be altered as one pleases simply by selecting the correct resistor value. This circuit uses the well-known 555 timer integrated circuit chip (refer to **fig. 2**). Varying the value of R4 will change the timing to suit one's requirements.

switching logic and timing

Referring to **fig. 1**, let's follow carefully through the complete sequence of events that occur when the main power switch is thrown. Activating the main power switch, S1, applies 120-volt and 240-volt single phase power to the supply. One hundred twenty volts is immediately applied to the 24-volt dc relay supply and blower. The air flow switch comes on, activating RY1. One set of RY1's contacts apply 120 volts primary power to tube-heater transformer T2, and a pilot light on the rf deck indicates the heaters are on. Resistor R2 in the transformer primary is used to adjust the voltage at the tube heater pins to the correct value. A second set of RY1's contacts makes 24 volts dc available at various relay coils and contacts, including the high-voltage primary relay RY2. RY3's field coil and contacts receive 24 volts, but the relay does not activate at this time.

Twenty-four volts dc are also applied to RY6 by RY1. The 90-second delay circuit of RY6 is now

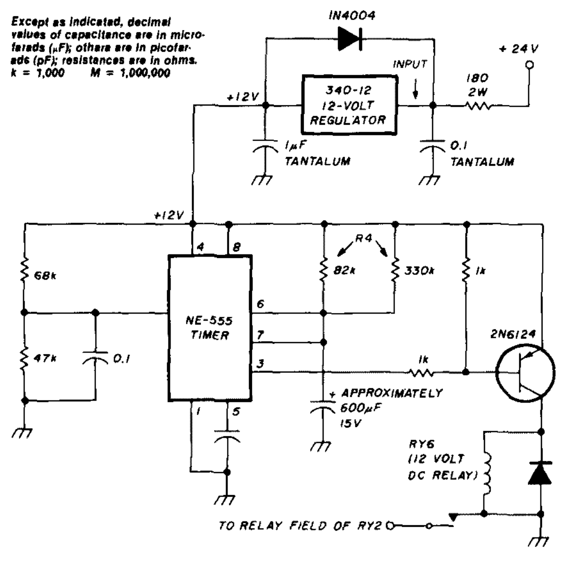


fig. 2. A 90-second time-delay relay circuit makes use of the popular NE-555 timer IC. This circuit allows the amplifier tube heaters to come up to temperature before high voltage is applied.

energized and the countdown begins. When the time has expired, RY6's contacts close, connecting the RY2's coil return to ground, activating it. The two sets of contacts of RY2 apply 240 volts ac to the high-voltage transformer primary through surge resistor R1. The filter capacitors start to charge and as they do, their impedance begins to increase. A third set of contacts of RY2 apply 24 volts to the one-half-second transistor timer delay circuit. In one-half second, the 2N2222 switching transistor conducts and completes the return circuit of the small, high-impedance coil of relay RY3, which in turn activates its small contacts, providing 24 volts to RY4. The heavy paralleled contacts of RY4 close, which shorts out the T1's primary inrush surge current resistor, R1. Full power is then applied to transformer T1. A second pilot light on the rf deck illuminates, indicating that full B+ voltage is present at the amplifier tube. However, no resting plate current will show on the plate meter as yet.

A third set of contacts on RY2 made 24 volts dc available at S2. (S2 is preferably located on the rf panel.) Throwing this switch applies 24 volts dc to RY5's field coil. However, RY5 does not activate because the field return must be closed by push-to-talk relay contacts from the transceiver. The two sets of contacts of RY5 apply 24 volts to the input and output antenna relays in the rf amplifier and also short out the amplifier's standby bias resistor. S2 on the rf panel in its OFF state prevents RY5 from being activated should the push-to-talk circuit in the transceiver be energized. This is necessary so that the exciter (or transceiver) can be tuned without activating the amplifier.

After the exciter has been tuned to frequency, reduce the carrier to zero, and activate S2 on the amplifier panel. RY5 then closes, shorts out the standby cutoff bias, and activates the antenna relay. The plate meter indicates standby plate current and the final amplifier is now ready to be tuned to frequency.

some final suggestions

There are a few points of interest that may not be evident in the schematic. First, it is important to have a 0.002 to 0.01 μF ceramic capacitor of appropriate voltage rating placed at each of the transformer primary terminals to ground. These caps prevent transients, other hash and rf from getting into the supply or onto the power lines.

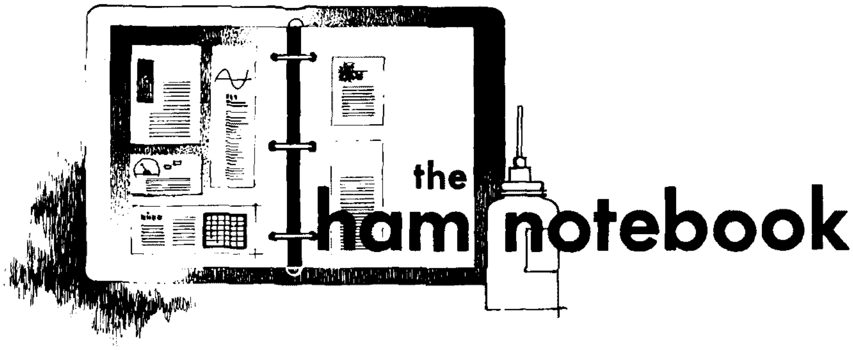
It is suggested that a good location for RY1 and RY5 would be on or in the rf deck. The 50-ohm resistor in the ground circuit of the B minus line should really consist of three 50-ohm resistors placed throughout the B minus circuit. Suggested locations would be: from the bridge rectifier circuit to chassis, from the supply cable connector B minus pin to ground, and one at the same connector point on the rf-deck. The use of several 50-ohm resistors could save your grid meter should one of the resistors become open.

It is a good idea to use more than one connector pin for B minus and ground connections and to run at least two separate wires for each from the power supply to the rf deck. It could save your life should one of the wires in the cables become open circuited.

Resistor R2 in the primary of tube-heater transformer T2 will probably be less than 30 ohms but should be about 20 watts. The resistance I required was about 12 ohms, so I connected it so that two portions of the one resistor were paralleled, increasing its power dissipation. Lastly, the terminal strip shown in my supply is a very handy addition for connecting all of the power wires. That's why I show extra terminals — use it.

The supply described here presently powers a newly completed 8877 amplifier. It is the final result of five separate kW amplifier and power-supply projects, each with its own theme and goals. The first four phases of this long project used Eimac tetrodes, all having screen supplies. Each was individual and different. I've been exceptionally well pleased with the last three phases of the project and as always, the last seemed to be the ultimate.

ham radio



a computer for the blind

Often a computer can be viewed as a huge breadboard wired by software. So if one is experimentally inclined yet blind, the computer would appear to be an ideal playground. Thus I suggested to my friend Randy, N8KL, that we attempt to adapt some micro for his use.

My AIM-65 has a user-alterable vector (DILINK) in the display routine, which would make a Morse-code-display routine an easy construction. However, a not insignificant portion of the cost of the AIM-65 is the "smart" LED display and the printer, both useless to the blind.

The machine that caught our attention was the Ohio Scientific OSI 1-P, which in its 8K BASIC form, can be bought for $349 — truly a remarkable value. Once it had been purchased, I tried in vain to wedge into the display routine a Morse-code echo. Next we turned to hardware.

From WD8DTL we borrowed a Xitex MRS-100 Morse-code transceiver and connected it to the OSI as in **fig. 1**; the computer and Xitex now communicated through TTL levels.

This arrangement was usable but not handy — the computer overran the 32-character buffer of the Xitex. So, following an idea of WA8LMF, we let the Xitex toggle the clear-to-send of the ACIA, as in **fig. 2**. If desired you can omit the emitter follower on the OSI board and pull C-T-S down wth a 1.5k. You must, in any case, break the jumper (W3) connecting pin 24 of the ACIA (U14) to ground.

The start-up procedure is as follows: turn on both the OSI and the Xitex. On the OSI type *BREAK*, *C*, *RETURN*, *RETURN*, *SAVE*, *RETURN*, and Morse will output. Reset the Xitex, then on the OSI type *$*, your desired speed in wpm, then *SPACE*. The display will now echo in Morse.

One negative note. The TTY output routines exist only in BASIC. You'll need a software assembler to do machine language programming. Randy and I will soon report to you on our success with a Braille printer.

C.R. Mac Cluer, W8MQW

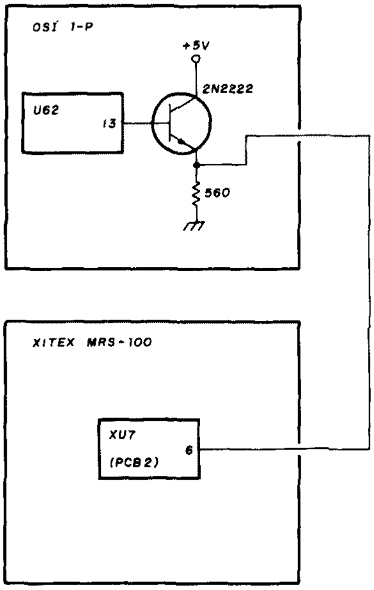


fig. 1. The display is echoed in Morse code.

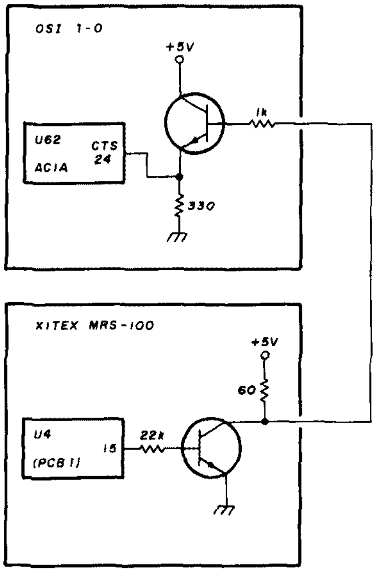


fig. 2. Handshake. Both transistors are 2N2222.

(Continued on page 70)

noise reduction for the SB-303 receiver

If you have a Heathkit SB-303 receiver, you may have noticed a rather high internal noise level. The mods described below will eliminate the noise, although at a sacrifice in audio output power. However, after the mods were made in my set, more than adequate audio was available for headphone operation. To make the modifications, refer to fig. 3 and proceed as follows:

1. Remove the cabinet, turn power on, and listen to the noise level using headphones.

2. Set function switch to STBY, rf and af gain controls to their full counter clockwise stops, and converter switch to VHF1.

3. Set mode switch to USB, AGC switch to FAST, preselector to peaked position on any band, and speaker disable switch to DISABLE position. Now the noise will be most pronounced in your headphones.

4. Remove the two white wires from the AUD OUT terminal, which is located on one of the three terminal strips for the i-f/audio amplifier circuit board on top of the unit. Refer to pictorial 13-14 in the Heath manual. Now the headphones will be completely silent.

5. Connect a 1-watt, 100-ohm resistor between the two white wires just removed and the AUD OUT terminal (**fig. 1**). Use insulation tubing.

Now you will notice substantial noise reduction through your headphones. You'll also notice a reduction in audio level when you set the controls and switches to their normal receiving positions.

6. Now set the controls and switches back to the positions described in **steps 2** and **3**. The hum and noise level will still be high. Place the unit upside down.

7. Connect one end of a piece of No. 14 (1.6 mm) hookup wire (about 10 inches or 25 cm long) to the ground terminal of the af gain control, now positioned at the lower left-hand corner. Route the wire along the chassis and connect the other end to the ground terminal of the CW SHIFT phone jack on the rear panel. This ground connection makes a good rf-current return and the receiver will become very quiet.

8. Now place the unit back to the normal operation position.

9. Connect a 2000-μF, 50-volt electrolytic capacitor across the +35 volt terminal and the ground terminal at the top of the chassis on the power supply, BFO, calibrator circuit board side. This completes the modifications.

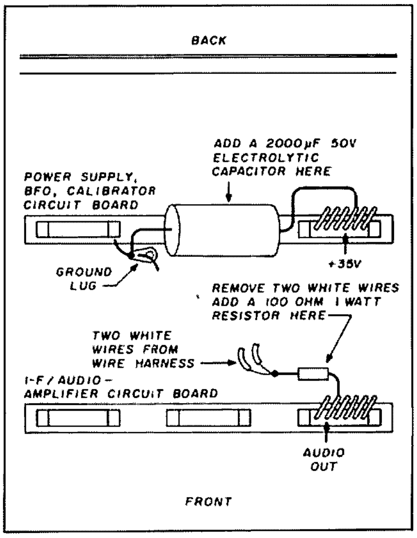


fig. 3. Modifications to the SB-303 to reduce noise.

My set is now almost completely free from hum and other noise. Operation of the af gain control is smoother, and its 10-o'clock setting produces ample gain for weak-signal reception.

I checked the set's sensitivity after the modification and found that I could copy signals as low as −20 dB.

Hajime Suzuki, (SWL)

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SALE — HW-16 $125 (w/crystals $150). 2 Johnson matchbox tuners, best $50, other (needs repair) $25. Heath 2 meter mobile amp $30. 10-40 vertical $25. You pay shipping. KA4EBW, Jim Howell, 18 Dan Street, Salisbury, NC 28144.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Williams, PO #7057, Norfolk, VA 23509.

VERY In-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

PURPLE HEART VETERANS: Organizing national Amateur Radio Chapter and Net to be affiliated with Military Order of the Purple Heart, Inc. For information and applications contact Clem Harris, KC5MM (ex WB5VDL), 6110 Pecan Trail Dr., San Antonio, TX 78249. (512) 699-1420.

BUY-SELL-TRADE. Send $1.00 for catalog. Give name, address, and call letters. Complete stock of major brands new and reconditioned amateur radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. (913) 381-5900.

DRAKE READOUTS: Direct digital readouts provide accurate 6 digit frequency display for Drake rigs. Model FR-4 for the "Twins" just $169.95. Model FR-4TR for the TR-3 and TR-4 series transceivers $179.95. Include $2.50 shipping and handling. e-tek, P.O. Box 625, Marietta, Ohio 45750.

REQUEST FOR INFORMATION: The Viroplex Company's records were destroyed by fire and the company has no way to determine the year of manufacture by serial number on their units. I would appreciate hearing from anyone having this kind of information. K6ARE, 1263 Lakehurst Rd., Livermore, CA 94550.

Coming Events

ACTIVITIES

"Places to go..."

IDAHO: The Fifth annual Treasure Valley Hamfest sponsored by the Voice of Idaho Amateur Radio Club and the Treasure Valley Radio Association, June 19 and 20, 9 AM Saturday to 3 PM Sunday, Mini-dome, Payette. $15.00 pre-registration, $20.00 registration at door includes breakfast, dinner and prize tickets. Swap tables, dealers, transmitter hunts, ladies' and children's activities, games, contests, prizes, banquet Saturday, breakfast Sunday, cocktail party Friday evening and picnic Saturday. Talk in on 147.84/24, (WB7NSE/R), 147.72/12 (K7OJI/R), 146.52 simplex. For information: Samuel K. Sower, N7DOV, 1909 Grant St., Caldwell, ID 83605. (208) 459-8132.

ILLINOIS: The Six Meter Club of Chicago's Silver Anniversary Hamfest, Sunday, June 13, Santa Fe Park, 91st and Wolf Road, Willow Springs. Advance registration $2.00; $3.00 gate. Swappers' row, picnicking, displays, refreshments, AFMARS meeting. First prize: color TV; second: IC-2A or Bearcat 210XL and other goodies. Talk-in on 146.52 or K9ONA/R 37-97. Advance tickets: Val Hellwig, K9ZWV, 3420 South 60th Court, Cicero, IL 60650.

INDIANA: The Indiana State Amateur Radio Convention in conjunction with the Indianapolis Hamfest and Computer Show, Sunday, July 11, Marion County Fairgrounds, southeast intersection I-74 and 465. Inside/outside flea markets. Separate computer show and flea market. Camper hookups available on grounds. Technical forums, club activities, ladies' activities. Gate ticket $4.00, for all activities and major prize drawing plus hourly prizes. For information: Indianapolis Hamfest, Box 11086, Indianapolis, IN 46201.

INDIANA: The Lake County Amateur Radio Club's 10th annual "Dad's Day" Hamfest, June 20, Lake County Fairgrounds, Industrial Arts Building, Crown Point. Prizes. Talk-in on 147.84/24 or 52. Tickets $2.50. Mail check to: Lake County ARC, c/o Walley Kozol, KA9FDC, 624 N. Rensselear St., Griffith, IN 46319.

MAINE: The third annual Yankee Hamfest, sponsored by the Yankee Radio Club, Saturday, June 19, 9 AM to 5 PM, Oxford County Fairgrounds, Oxford. Admission $1.50. Camper hookups available Friday and Saturday nights, $3.00 per night. Flea Market, displays, women's activities, swap tables, CW contest, food available, many prizes. Ham of the Year Award. Talk-in by Don Dean, W1BYK on 146.28/88 and 146.52.

MICHIGAN: The annual Monroe County Radio Communications Hamfest, June 13, 8 AM to 3 PM, Monroe Community College, Raisinville Road, Monroe. Tickets $2.00 gate, $1.50 advance. XYLs and children free. Free parking. Contests, auctions and displays. Plenty of table space. Talk-in on 146.13/73 and 52. For information: Fred Lux, WD8ITZ, P.O. Box 982, Monroe, MI 48161 or call 1-313-243-1088 Hot Line.

NEW JERSEY: The Raritan Valley Radio Club's 11th annual Hamfest and Flea Market, June 19, 8:30 AM to 4 PM, Columbia Park, Dunellen. Door prizes and snack bar. Admission $3.00 sellers; $2.00 lookers. Talk-in on 146.625/025 (W2OW) and 146.52 direct. For information call Bob, KB2EF, 201-369-7038.

NEW YORK CITY: The annual Hall of Science Amateur Radio Club's indoor/outdoor, rain or shine Hamfest, Sunday, June 13, 9 AM to 4 PM, Municipal Parking Lot, 80-25 126th Street (1 block off Queens Blvd.), Kew Gardens, Queens. Sellers' donation $3.00. Buyers $2.00. XYLs, kids free. Walk/talk-in on 145.520. For information KA2DTB, (212) 738-8887.

NEW YORK: The Genesee Radio Amateurs' second annual ARRL approved Batavia Hamfest, Sunday, July 11, 7 AM to 5 PM, Alexander Firemen's Grounds, Route 98, Alexander. Registration $2.00 advance, $3.00 gate. Flea market $1.00. Prizes, exhibits, OM and YL programs, contests, food, overnight camping, boat anchor auction at 3 PM. Fun for all. Talk-in to W2RCX on 4.71/5.31 and 52 simplex. For advance tickets make checks payable to: Batavia Hamfest, c/o GRAM, Inc., Box 572, Batavia, NY 14020.

NEW YORK: The Staten Island Amateur Radio Association's Flea Market, June 12, 9 AM to 3 PM, All Saints Episcopal Church, Staten Island. Free admission for buyers. Sellers $3.00 per space, own table. $1.00 for electricity. Raffle, refreshments. Talk-in on 146.52 and 146.28/.88. For information SASE to: George Rice, Jr., WA2AMJ, 480 Jewett Ave., Staten Island, New York 10302.

More Details? CHECK-OFF Page 92

NORTH DAKOTA/MANITOBA: The 19th annual International Hamfest, July 10 and 11, International Peace Gardens between Dunseith, North Dakota, and Boissevain, Manitoba, at the Canadian Pavilion on the north side of the Gardens. Excellent camping available. Transmitter hunts, mobile judging, CW and QLF contests, flea markets, seminars, Saturday night dance, Sunday morning breakfast, lots of prizes and more. For information contact WD0GMD or WD0GRC.

OHIO: The 8th annual Hall of Fame Hamfest, Sunday, July 18, Nimishillen Grange, 6461 Easton Street, Louisville. Tickets $2.50 advance, $3.00 gate. Under 16 free. Flea market opens 9 AM. Reserved tables available for rent. Awards, forums, food, dealers, XYL activities and more. Mobile check-in on 146.19/79, 146.52/52 simplex, and 147.72/12. For tickets/information: WA8SHP, 10877 Hazelview Avenue, Alliance, Ohio 44601. (216) 821-8794.

OHIO: The Lancaster and Fairfield County Amateur Radio Club's annual Lancaster Hamfest, Sunday, June 20, 9 AM to 5 PM, Fairfield County Fairgrounds, Lancaster. Tickets $2.00 advance, $3.00 door. Hourly drawings, refreshments available. Flea market tables available or bring your own. Talk-in on 147.03/63 or 146.52 simplex. For information: Box #3, Lancaster, Ohio 43130.

OKLAHOMA: The 25th reunion of the VHF Radio Amateurs who were members of the Oklahoma Central 6 Meter Club, later known as the Central VHF Club. Please send name, address and present call, and whether you intend to attend the reunion, to: T.W. Stevens, W5VCJ, P.O. Box 976, Edmond, OK 73083. The reunion will be held at the same time but not in conjunction with the Oklahoma City Ham Holiday on the last weekend in July.

OREGON: Lane County Ham Fair, July 17 and 18, Oregon National Guard Armory, 2515 Centennial, Eugene. Doors open 8 AM. Swap and shop tables $5.00. 2 meter bunny hunt, women's activities, children's corner, computer demos, all day snack bar, free parking for RVs, no hookups. Saturday potluck supper. Grand Prize: Icom 730 low band Mobile rig and many other prizes. Tickets purchased before July 1 receive one extra drawing ticket free. Talk-in on 146.28/88, 147.86/26 and 52/52. 3.910 HF. For tickets send checks to Eunice Brown, WA7MOK, 2456 Corral Ct., Springfield, OR 97477. Phone 747-7939.

PENNSYLVANIA: Harrisburg annual Firecracker Hamfest, Sunday, July 4, sponsored by the Harrisburg Radio Amateur Club, Shellsville VFW Picnic Grounds, exit 27, interstate 81, north of Harrisburg. Talk-in on 16/76 or simplex 52/52. Tables available or bring your own. Admission: $3.00. XYL and children free. Tailgating $1.50. Door prizes and Grand Prize drawings. For details: KA3HZW, 131 Livingston Street, Harrisburg, PA 17113 or phone (717) 939-4957.

PENNSYLVANIA: The Nittany Amateur Radio Club Ham Festival, July 10, 8 AM to 4 PM. First prize: Radio Shack color computer; second prize: reconditioned Tempo 2-meter amplifier; many more prizes. Talk-in on 146.16/.76, 146.25/85 and 146.52. Tickets $3.00; tailgating/tables $5.00. Information from NARC, P.O. Box 614, State College, PA 16801.

PLAYBOY RESORT at Great Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07831.

SOUTH DAKOTA: The annual South Dakota Hamfest, sponsored by the Black Hills ARC, July 10 and 11, Surbeck Center, SD School of Mines & Technology, Rapid City. Pre-registration $7.00; $8.00 door. Prize drawing for pre-registrants. Free tables for flea market. Forums, contests, picnic, prizes. W0BLK call-in 34/94. For information: Rudy, WB0PWA, Black Hills ARC, 4822 Capitol, Rapid City, SD 57701.

WEST VIRGINIA: Hamfest WV's "biggie". TSRAC Wheeling WV Hamfest, Sunday, July 25, 9 AM to 4 PM. Major and door prizes, indoor dealer displays, flea market, auction, refreshments. Park attractions — family affair. Reasonable motel accommodations, catch WWVA Jamboree, Saturday night. Donation $2.00, children 12 & under free. Contact: TSRAC, Box 240, RD 2, Adena, OH 43901.

WISCONSIN: Swapfest '82 sponsored by the South Milwaukee Amateur Radio Club, Saturday, July 10, 7 AM, American Legion Post 434, Oak Creek. Tickets $2.00. Buy, sell, swap. Refreshments, prizes, camping. Happy Hour (free beer and soda). First prize $100; second prize $50 plus hourly prizes. Talk-in WA9TXE/9 146.94. For details and a map: South Milwaukee Amateur Radio Club, P.O. Box 102, South Milwaukee, WI 53172.

BRITISH COLUMBIA: Hamfest '82 sponsored by the Maple Ridge ARC, July 10 and 11, Maple Ridge Fairgrounds, 30 miles east of Vancouver. Hams $5.00; non-Hams over 12 years $2.00. Food, prizes, swap & shop, displays, bunny hunt, ladies' and children's programs and much more. Main prize Kenwood TR-2500. Camper

space available. Talk-in on 146.34/94 and 146.20/80. For information and registration: Maple Ridge ARC, Box 292, Maple Ridge, BC V2X 7G2.

OPERATING EVENTS

"Things to do..."

JUNE 19: The Cape Fear Amateur Radio Society of Fayetteville, NC, will operate a special event station, club call WB4YZF, from the 14th annual National Hollerin' Contest, Spivey's Corner, NC. Operation will be on 7235 MHz between 1300-2100 UTC. For a special certificate send QSL and $1.00 US to: Sonny Bartron, Rt. 2, Box 532, Fayetteville, NC 28301.

JUNE 26 & 27: A special events day of the Tri-City Amateur Radio Club will be held at the Goodnoe Wind Turbine Site, ten miles east of Goldendale, WA. The power usage is sponsored and special permission granted from NASA, Boneville Power Administration, Department of Energy, and Boeing Aircraft Co.

JULY 3 & 4: The Hannibal Amateur Radio Club's second annual special certificate from the National Tom Sawyer Days celebration in Mark Twain's boyhood home town, Hannibal, MO. House 1500-2100 UTC both days. Frequencies: Phone 7.245, 14.290, 21.400, 28.770. CW 7.125 and 21.125. The club is also observing its 50th anniversary. For a certificate, send large SASE and QSL card confirming contact to: Hannibal Amateur Radio Club, WØKEM, 2108 Orchard Avenue, Hannibal, MO 63401.

JULY 4: Commemorative Amateur Radio Station, Bonfield, Illinois, Centennial Celebration. Frequencies: 223.50, 144.250, 146.520, 50.115, 28.600, 21.400, 14.325, 7.275, 3.8-3.9. SASE to WB9WOC, QSL Manager.

JULY 4 & 5: The High Plains ARC will have a special events station K7YPT at historic Fort Laramie, Wyoming, starting 0000Z, July 4 to 0000Z, July 5. Frequencies: Phone 28550, 21300, 21360, 14250, 14300, 7250, 3850, 3900. CW 50 kHz up from lower band edge. Novice — middle of band. For a special certificate for QSL send large SASE to: K7YPT, P.O. Drawer T, Torrington, WY 82240.

OCTOBER 31 TO NOVEMBER 10: The Penn Wireless Association is sponsoring a HAM DXPEDITION AT SEA aboard the Royal Caribbean Line's Sun Viking. All hams are invited to participate in this exciting adventure. For more information contact: Bill Buckley, WA2ALG, 1158 Oxford Valley Road, Levittown, PA 19057. See April HR, page 95.

More Details? CHECK—OFF Page 92

ham radio TECHNIQUES

Bill Orr W6SAI

Spring is on the way, and with the advent of milder weather the thoughts of many Amateurs turn toward antennas. A lot of interesting antenna experiments and tests should be underway this summer. And all of them will probably include the use of an SWR meter to help determine antenna operation.

My discussion of the SWR meter and its problems in the April column raised several inquiries concerning an accuracy test for the SWR meter. How can the owner of such a device determine if the readings he gets are meaningful? Fortunately, there is a simple and inexpensive test procedure that will determine the excellence of any SWR meter. You can run the test in a few hours' time.

Consider the situation in **fig. 1**. Three SWR meters are placed at random spots along a transmission line to an antenna. At any given value of SWR the three devices should provide the same indicated reading. Does this happen in real life? Probably not. In addition to inherent error mechanisms such as meter movement and the linearity of the diodes in the SWR indicators, the directivity of the individual couplers in each SWR meter enters the picture. By directivity I mean the ability of the coupler to discriminate between opposite directions of rf power flow. Since most simple SWR meters have both a "forward" and a "reverse" coupler built in them, the directivity factor assumes great importance.

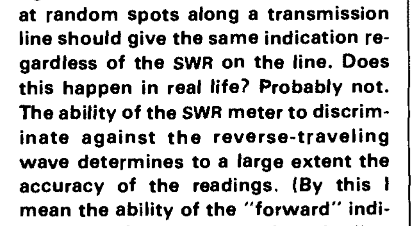


fig. 1. Three identical SWR meters placed at random spots along a transmission line should give the same indication regardless of the SWR on the line. Does this happen in real life? Probably not. The ability of the SWR meter to discriminate against the reverse-traveling wave determines to a large extent the accuracy of the readings. (By this I mean the ability of the "forward" indication to discriminate against the "reverse" indication, and the ability of the "reverse" indication to discriminate against the "forward" indication). This discrimination is termed directivity.

A sketch of a representative SWR meter showing the two couplers is given in **fig. 2**.

the SWR meter test

The idea shown in **fig. 1** is a good check for an SWR meter. Move the meter along the transmission line and note any change in indicated SWR. This, however, is a cumbersome idea that is hard to accomplish in most cases, and the results may not be reproducible because of the interaction between the field of the antenna and the outer shield of the transmission line.

A more practical test for the SWR meter is shown in **fig. 3**. A deliberate mismatch is measured through various lengths of transmission line. A dummy load is used to eliminate the interaction between antenna field and the line. The degree of mismatch SWR is known and repeatable. And

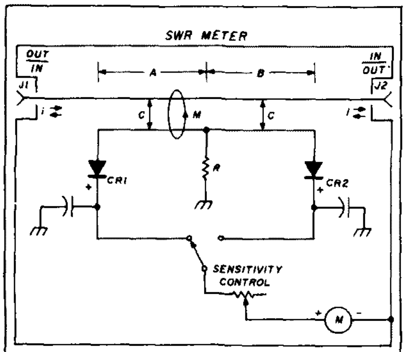


fig. 2. Simple SWR meter uses two direction couplers (A end B) to sense forward and reflected wave components in a transmission line. Reflected components of voltage and current are 180 degrees out of phase while the forward components of voltage and current are in phase. Inductive (M) and capacitive (C) pickup between transmission line and pickup line provide voltage that is rectified by diodes (CR1,CR2) to provide "forward" and "reflected" readings on meter M. Couplers are terminated in a common resistor, R.

best of all, the test is easy to run and inexpensive to set up.

Note that a second harmonic filter is required between the signal generator (your transmitter or exciter) and the test setup. This is because the second harmonic energy, small though it may be, is sufficient to disrupt the results of the investigation. See **fig. 4**.

The mismatched load is made up of a 50-ohm dummy load and a quarter-wave section of 75-ohm coaxial line. The line section serves as an impedance transformer, providing a terminal impedance of 112.5 ohms at the open end. If this value of load is measured through a 50-ohm SWR meter, the indicated SWR should be the ratio of the load to the line impedance, or:

$$\frac{112.5}{50} = 2.25\text{-to-}1$$

The test is conducted as shown in the illustration. The mismatch load is measured directly, and then remeasured through various lengths of 50-ohm line. If the SWR meter is perfect (and none of them are) the SWR reading will remain constant at each observation point. The amount of variation in the indicated SWR reading from the true reading determines the excellence of the SWR meter.

preparing for the test

It is understood that the test is run at 14.0 MHz in this example. The 75-ohm mismatch line section is made from an 11-foot 7-inch (3.54-meter) section of either RG-59B/U or RG-11/U. (Other versions of RG-59 coax are not suitable, as their impedances may be as low as 73 ohms.)

Suitable connectors are placed on each end of the line and line length is measured from tip to tip of the center conductor. Next, three sections of 50-ohm line are made up. Two are one-eighth-wavelength long (5 feet 9-1/2 inches, or 1.77 meters) and the third is one-quarter-wavelength long (11 feet 7 inches, or 3.54 meters). Again, suitable plugs are placed on the line and length is measured from tip to tip of the center conductor. An accuracy of plus-or-minus one-half inch is satisfactory. Suggested cable types are RG-8A/U, RG-213/U, RG-58/U, or RG-58C/U. Don't use the old cable designation of RG-8/U or "RG-8-type" cable. That usually runs close to 52 ohms impedance.

When the cables are complete, label the 75-ohm cable A, the two short 50-ohm cables B and C, and the long 50-ohm cable D. You can make

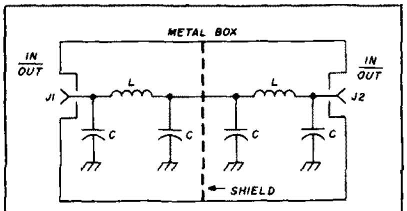


fig. 4. A harmonic filter for 14 MHz. An attenuation of about 30 dB is provided for the second harmonic. Each capacitor (C) is 220 pF. Each inductor (L) is 0.55 μH seven turns, No. 16 (1.3-mm) wire 3/4-inch (19-mm) diameter, 7/8-inch (22-mm) long. Suitable coaxial connectors are placed on the ends of the box (J1,J2) and the filter sections are separated by a shield plate placed across the middle of the box. Filter wire passes through a small hole drilled in the shield.

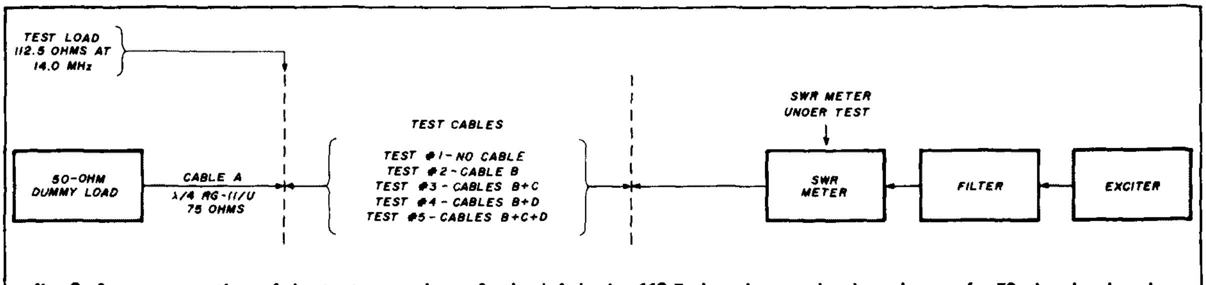


fig. 3. A representation of the test procedure. At the left is the 112.5-ohm dummy load made up of a 50-ohm load and a quarter-wave section of transmission line acting as an impedance transformer. At the right is the test setup for the SWR meter. See *fig. 4* for filter data. The test arena is the area between the vertical dashed lines. Five tests are conducted: One test requires no interconnecting lines, and the other four tests require line sections representing 1/8-, 1/4-, 3/8-, and 1/2-wave line sections.

TEST NUMBER	CABLES	LENGTH (λ)	INDICATED SWR
1	0	0	3.35
2	B	1/8	2.00
3	B+C	1/4	1.50
4	B+D	3/8	2.75
5	B+C+D	1/2	3.35

fig. 5. Representative SWR readings recorded with a "Brand X" SWR meter as various cable lengths are added between the meter and an unmatched load, as shown in *fig. 3*. Actual value of SWR in each case is 2.25-to-1.

up paper labels and tape them directly over the jacket of the lines with transparent tape.

The last step is to make up the second harmonic filter. A suitable filter is shown in **fig. 4**. It is made of air-wound coils and mica capacitors and built in a small metal box. A shield is placed between the filter sections, as shown, and suitable coaxial receptacles are placed on the ends of the box. The filter is rated for a power level of about 150 watts.

running the test

Test number 1 consists of measuring the SWR directly at the end of cable A. Make up a suitable chart and record all your readings on it. Later, a graph can be drawn from the chart data (**fig. 5**).

For test number 2, cable B is added between the SWR meter and cable A, and an SWR reading is taken and logged. Test number 3 consists of using cables B and C in series. Test number 4 consists of cables B and D in series. Test number 5 consists of using cables B, C, and D in series. The numbers in **fig. 5** were derived by testing a cheap, imported SWR meter.

What you have just finished doing, in effect, is to add eighth-wavelength sections of coax line between the "mismatch" line section and the SWR meter. This is electrically equivalent to moving the SWR meter along the line, as discussed in **fig. 1**.

results of the test

A representative test on two SWR meters is charted in **fig. 6**. The second instrument is a Bird 43 coupler.

The variations of the indicated reading from the true SWR values are obvious and startling!

This graph explains one of the reasons that the indicated SWR will vary with the placement of the instrument in the line. It also gives lie to the popular but incorrect belief that changing line length changes the SWR on the line! Changing line length changes the indicated SWR reading to a degree, depending upon the accuracy of the SWR meter, but the actual SWR on the line remains the same. (It is true that actual SWR will decrease with line length due to line attenuation, but this is another matter and may be ignored in the high-frequency spectrum. Most Amateur handbooks provide tables of line attenuation for those interested in pursuing that subject further.)

interpreting the results

The graph shows that even an excellent SWR coupler such as the Bird

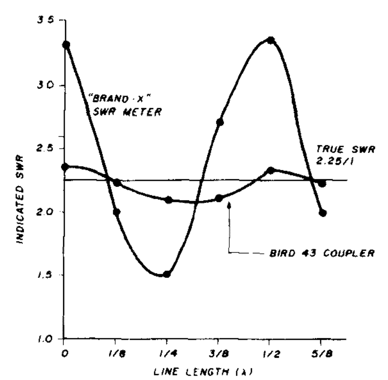


fig. 6. Using the data in *fig. 5*, plus a second test run on a Bird 43 coupler, produces the chart shown. The indicated SWR measurements (Y-axis) are plotted against cable length (X-axis). An additional section of cable was used to extend the plot to 5/8-wavelength. Note that the plot is not symmetrical about the true SWR value.

provides a reading that varies with line length to a small degree. The inexpensive "Brand-X" SWR meter, however, is not to be trusted. The indicated reading varies between a low value of 1.5-to-1 and a high value of 3.35-to-1 for a true SWR value of 2.25-to-1. You can get almost any reading you wish by merely moving the instrument back and forth along the line!

The test results are based upon a single frequency measurement (14.0 MHz) and the variations in SWR reading change with frequency, growing worse as the frequency of operation is raised. This is why most cheap SWR meters provide gibberish at 10 meters and higher. The Bird coupler, on the other hand, has frequency-rated, plug-in detectors which provide good accuracy in the VHF and UHF regions.

The indicated SWR excursions determined by the just-completed tests can be used to determine the directivity factor of the SWR meter (directional coupler), with the aid of **fig. 7**. (This drawing is reproduced, with thanks, from the November, 1959, issue of *QST*. It was in an article entitled "Possible Errors in V.S.W.R. Measurement" by Louis D. Breetz, W3KDZ/W8QLP.)

The directivity is found by locating the maximum excursions of SWR on the graph you have made and finding them on the Y-axis (vertical) of **fig. 7**. For example, the Bird Coupler has a SWR excursion of 2.35-to-1 to 2.1-to-1. Find the true value of SWR (2.25-to-1) on the X-axis (horizontal) and proceed upward until you cross the points you have located on the Y-axis. This indicates a directivity of almost 40 dB, which is excellent.

On the other hand, the indicated maximum SWR excursions of the "Brand-X" SWR meter are 3.35-to-1 and 1.5-to-1. Locating these points on **fig. 7** indicates a directivity of about 15 dB, which is very poor!

As you can see from an inspection of your graph, and also **fig. 7**, a directivity of about 40 dB is required to

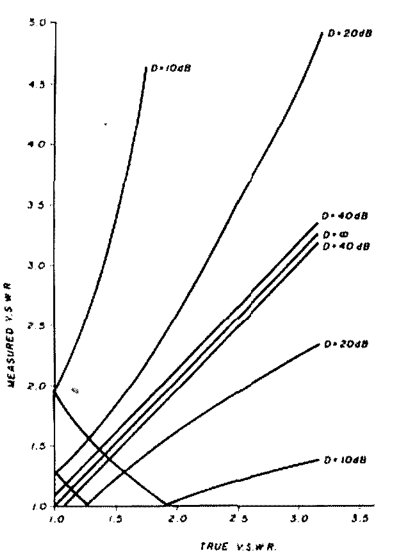


fig. 7. A reproduction of the chart in the November, 1959, issue of *QST*, showing the relationship between true SWR and measured SWR. A good directional coupler has a directivity figure of close to 40 dB. (Reprinted courtesy of *QST* magazine).

give a meaningful SWR reading, and even that degree of excellence allows an error of about 5 percent in the reading. Note, too, that the indicated SWR curve plotted for both instruments is not symmetrical about the true SWR value, further complicating interpretation of data to a degree.

SWR meter wrap-up

This simple experiment illustrates that only a good SWR meter (or directional coupler, if you wish) will provide meaningful SWR numbers. My April column pointed out some of the pitfalls in making SWR measurements. This column explores the limitations of the SWR meter itself. Armed with this information, it should be possible for any Amateur to make *meaningful* SWR measurements.

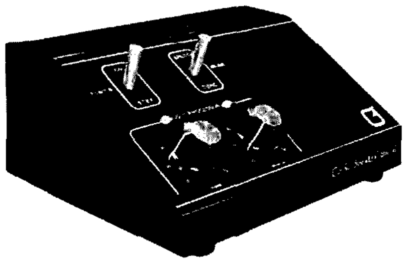
(Note: Thanks to Willy Sayer, WA6BAN, for deriving this test setup and for making the measurements on the two SWR meters.)

ham radio

NEW products

audio processor/ descrambler

The Grove Enterprises DSC-2 Code Breaker is a second-generation audio processor designed for use with scanner or shortwave receivers when monitoring speech inversion scrambling systems. This specialized accessory allows restoration of speech inverted messages to recognizable transmissions.



The low cost of the DSC-2 makes it ideal for monitoring posts that need to be alerted to operations of other departments using speech inverted security systems when a scrambled reply is not necessary (the DSC-2 is designed for receive only). Surveillance and other low profile intelligence operations will find the DSC-2 Code Breaker most valuable when monitoring speech-inverted messages frequently used by suspects either on mobile radiotelephone or over telephone lines when used in conjunction with standard electronic monitoring equipment.

An additional feature of the new DSC-2 is a tunable audio notch filter which permits the user to further clarify signals by removing masking tones which are often used to detract from recognizable speech. When used with shortwave receivers, this same audio notch filter is effective in removing heterodyne interference from adjacent-frequency signals without the need for using narrow i-f selectivity and its attendant muffled quality.

Additionally, the DSC-2 may be used for reversing sidebands to reduce interference. Similarly, close-spaced CW signals may be isolated by adjusting the receiver to zero-beat the unwanted signal, then the Code Breaker is adjusted to change the pitch of the received signal to any desired frequency for comfortable copy.

For more information contact Grove Enterprises, Inc., Dept. D, Brasstown, North Carolina 28902; telephone 704-837-2216.

AEA model MM-2 keyer

Advanced Electronic Applications, Inc., announces the latest generation of MorseMatic™ keyer, the MM-2. The MM-2 is a full-feature paddle input keyer that offers virtually all the features of the MM-1 predecessor plus CMOS memory and at a new low price. The new MM-2 features two powerful pre-programmed microcomputers with copyrighted AEA "firmware."

Like the MM-1, the new MM-2 offers more exclusive features than any other keyer on the market: an automatic serial number generator, an automatic beacon mode, and an automatic speed increasing Morse trainer mode.

The MM-2 permits the operator to vary all of the following from the control keypad: stepped variable monitor tone; dot ratio; dash ratio (for full independent weighting control); dot memory enable or disable; dash memory enable or disable; semi-automatic ("bug") or full automatic operation; speed select from 02 to 99 WPM to 1 WPM increments; and more.

memory

Like its predecessor, the new MorseMatic MM-2 keyer offers a message storage mode with many exclusive AEA features never before offered. Some of these include: ten soft-partitioned™ memory locations; selectable real time message loading or automatic word space loading mode; additional word or character space insertion for perfect formatting in the automatic words space mode; and much more.

The new model MM-2 MorseMatic keyer comes in a handsome metal package that offers the same rf protection that earned the MM-1 such a good reputation for being "bullet-proof." The MM-2 also has a new extended-life, highly reliable sixteen-button keypad. All integrated circuits are mounted on sockets for easy repair if ever necessary. The unit operates from 10 to 16 Vdc or use the optional AEA model AC-1 wall adaptor for 110 Vac.

Perhaps the biggest change between the MM-2 and MM-1 is the price. The new model MM-2 carries a manufacturer's suggested price of $139.95. For further information, contact Advanced Electronic Applications, Inc., P.O. Box 2160, Lynnwood, Washington 98036; telephone 206-775-7373.

portable transceiver

The Santec ST series of radios (both the 2-meter and 440-MHz versions) are the first units to incorporate accurate digital clocks within the programs to control the operation of the radio. The ST-144 contains some of the finest features and easy-to-use functions to be found in a 2-meter portable.

The ten memories store both the frequency information and the instructions to the transmitter as to which way to offset the transmit frequency for repeater use. Once this information is set, the operator no longer has to worry about the offset switches. Bandscan is handled by three different microprocessor programs. The manual mode is for stepping through the band one step at a time; the search mode will automati-

NEW products

cally find the first station talking and stop scanning further. In addition, there is the scan mode which steps through the band and pauses for a while at each busy station to sample the conversation and then moves on. The upper and lower frequency limits of this scan are settable by the user through stored values in the microprocessor.

The microprocessor itself is a very versatile CMOS four-bit CPU. This means that it doesn't eat much current, and it can handle any of the data functions and drive the crisp, clear liquid crystal display as well as process all the commands given it by the user through the keyboard. In addition, if you turn the radio off and put it down, it can stay there for about six months before it needs to be recharged — and it can still remember what you told it to memorize six months before!

For those who are involved in the public service programs of MARS or CAP, the ST-144/uP provides frequency coverage external to the 2-meter Amateur band down to 142.000 MHz and up to 149.995 MHz. In this band range there are three selectable power levels of 100 mW, 1 watt (medium), and 3.5 watts (high).

Memory one is treated as a priority memory in the SCAN mode and signals on this frequency (whatever you stored there) are given priority treatment. When you're listening to one channel at a time, the computer detects an absence of activity and turns off the unneeded circuitry of the unit. At a later time, the computer checks to see if the circuitry is again called for and returns the radio to normal operation. This results in a very low receiver current drain in quiet standby of only 8 mA. Add to this the full sixteen-key keypad, the variable offsets and the big 500 mA-hr (8 cell) NiCad pack plus the easy installation of tone burst or subaudible tone and you have the most exciting, most versatile radio to come along yet.

For more information, contact Encomm, 2000 Avenue G, Suite 800, Plano, Texas 75074; telephone 214-423-0024.

IC-730 HF transceiver

ICOM announces the IC-730 compact solid state high-frequency transceiver. The IC-730 is specifically designed for the budget-minded ham. It's priced at $829.00, making it affordable as a second transceiver for mobile/portable operation, or as the main high-frequency base station transceiver.

The IC-730 is compact, only 9.5 × 3.7 × 10.8 inches. It has 10-80-meter frequency coverage including all three new WARC bands; it has fully

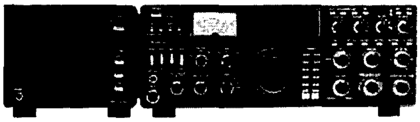
synthesized tuning for stability in mobile operation (1 kHz, 100 Hz, 10 Hz steps). Other features include dual VFOs standard; eight-frequency memory storage (one frequency per band); fully solid-state circuitry with automatic final protection; and i-f shift standard with passband tuning optional.

For more information, write ICOM, Suite 307, 3331 Towerwood, Dallas, Texas 75234.

TS-930S

Trio-Kenwood has just announced the new top-of-the-line model TS-930S all solid-state high frequency transceiver. Designed to cover all Amateur bands from 160 through 10 meters, the TS-930S also incorporates a 150 kHz to 30 MHz general-coverage receiver having an excellent dynamic range.

Among the more interesting features to be found on this model is an automatic built-in antenna tuner, dual digital VFOs, eight-memory channels, dual model noise blanker, i-f notch filter, fluorescent tube display, rf-type speech processor, rf step attenuator, 100-kHz marker, and voice controlled operation. Special circuitry is also in-

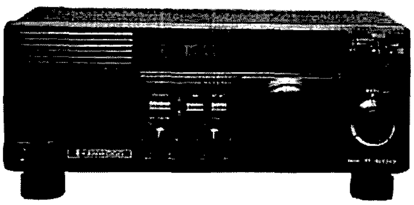


corporated that allows operator adjustment of the i-f passband characteristics for best rejection of interfering signals, as well as a tunable audio filter for CW reception. Power input is 250 watts PEP SSB, 250 watts dc on CW, 140 watts dc on FSK, and 80 watts dc on a-m. The built-in power supply operates on 120, 220, or 240 Vac only.

For further information, write Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

general coverage receiver

Trio-Kenwood Communications has just announced a new general-coverage communications receiver, the Model R-600, covering 150 kHz to 30 MHz in thirty bands. It will be available in mid December. The use



of PLL synthesized circuitry results in highly accurate frequency control and maximum tuning ease. The unit features an easy-to-read digital display, a-m, SSB, and CW reception, built-in i-f filters, noise blanker, rf attenuator, S-meter, and front mounted speaker. It can be operated from power sources of 100, 120, 220, and 240 Vdc, 50/60 Hz. Operation on 13.8 Vdc is also possible, using the optional DCK-1 dc power cable kit.

For more information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90220.

Supercw

Supercw offers computer-aided-instruction in International Morse Code with sound and graphics. You should be able to reach 5 WPM in 12 hours, 13 WPM in 48 hours, and 20 WPM in 72 hours (time varies with users).

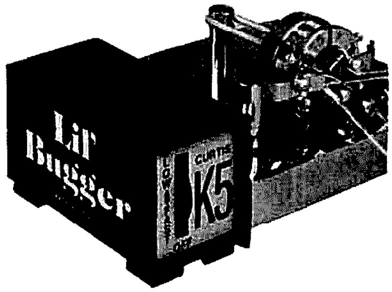
Features include introduction to International Morse Code, individualized learning methodology, random burst word practice, unlimited random word copying, and lots more.

Supercw is compatible to TRS-80 Model I or Model III, 48k and one disk drive. For more information, contact Frontier Enterprises, 3511 Gallows Road, Falls Church, Virginia 22042; telephone 703-573-8086.

NEW products

flea-size keyer

The tiny but rugged low-priced keyer from Curtis Electro Devices, the "Lil' Bugger," is only 1.5 inches square, 3 inches deep, and 3.5 ounces in weight. It offers many of the features found on full-sized keyers, plus a few of its own. The front panel contains only a thumbwheel speed control. Sidetone pitch, volume and weighting are adjustable internally via small trimmers. The tungsten output relay will easily key any Amateur transmitter, including the really tough cases such as old shipboard transmitters.

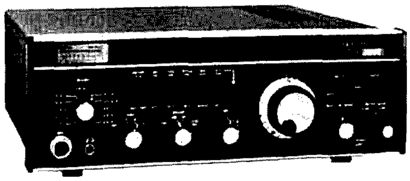


Jacks are provided for the keyline, sidetone output, and an external ac adaptor, although the case contains a compartment for an ordinary 9-volt transistor radio battery. The standard model, K5, is equipped with the Curtis 8044 chip. A second version of the unit (model K5B), uses the new Curtis 8044B IC, which provides the squeeze keying characteristics of the Ten-Tec, Heath, Nye and Accukeyer. Provision for a straight key is also made.

Both the K5 and K5B are priced at $39.95 plus shipping and are available from stocking dealers or direct from the factory. For more detailed information, contact Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040 or telephone 415-494-7223.

TR-5

The R.L. Drake Company announces the introduction of the new TR-5 Amateur Radio. This solid-state transceiver is broadbanded, operates on single sideband or CW, and covers all the Amateur bands, even the proposed 12, 17, and 30 meter bands.



Features include excellent sensitivity and selectivity, high dynamic range, digital frequency readout, and full break-in CW operation. AGC time constants are selectable and RIT is front panel selectable. Most Drake 7-line accessories are compatible. Nominal power input is 150 watts. Price is $1099.

For more information, contact R.L. Drake Company, 540 Richard St., Miamisburg, Ohio 45342; telephone 513-866-2421.

low-cost etching system

Stellmaker Enterprises has designed a high-quality power etching system that is reasonably priced. The kit includes an air pump, air disperser, base with support for 4½-pint plastic tank with cover, mounting screws, and all necessary instructions.

This compact system will etch PC boards up to 6 × 6 inches, the size featured in most magazine articles. The acid agitated by the air pump makes for fast and more even etching.

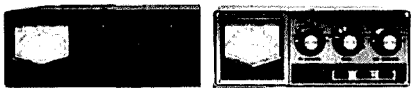
This kit sells for $34.50 plus $3.50 shipping and handling from Stellmaker Enterprises, 250 Pequot Trail, Westerly, Rhode Island 02891; telephone 203-599-1283.

NEW products

manual antenna tuners

Daiwa announces two new manual antenna tuners. The CNW-518 is a lightweight, rugged tuner rated at 2.5 kW (PEP), 1 kW CW (50 percent duty). It will match unbalanced lines from 10 to 250 ohms impedance and features 80 through 10 meter coverage *including* the new WARC bands. Features include attractive styling and planetary gearing. Insertion loss is less than 0.5 dB.

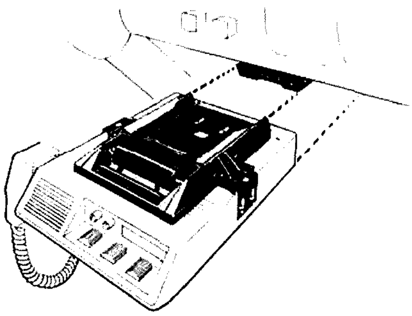
The new CNW-18 is rated at 500 watts (PEP), 200 watts CW, and incorporates the same features as the CNW-518 except planetary gearing. Both manual tuners feature the unique Daiwa cross needle meter that



shows forward power, reflected power, and resultant SWR at a single glance. For more information, contact EMCM, 858 E. Congress Park Dr., Centerville, Ohio 45459, or telephone 513-434-0031.

Larsen Quik Change

Larsen Antennas' new Quik Change Radio Mount system lets you change your mind — and your radio — fast. The innovative new mount permits temporary expansion of a delivery fleet, interchangeable use on farm equipment, or easy removal for protection against theft from unattended vehicles. It's a flexible product with flexible use. Transfers take only a minute. Radio malfunctions can be checked quickly and replacements installed easily in any vehicle. The Quik Change is tough enough to stand heavy equipment vibration.



There are no manual connections, just a simple latch release that disconnects the positive power lead, then the ground and speaker leads and the antenna connection. Reinsertion connects positive power last to protect the radio. First-class connectors are used throughout with connections provided for power, ground, and speaker screw terminals.

For more information, contact Larsen Antennas, P.O. Box 1799, Vancouver, Washington 98668.

VHF fm transceivers

Hamtronics, Inc., well known for high quality fm transmitter, receiver, and power amplifier modules, now has a complete VHF fm transceiver all on one PC board. The new model FM-5 transceiver kit is available for the 6-meter, and 220-MHz ham bands and may also be used in some countries on adjacent commercial bands. It operates on up to five channels at 10 watts output. The receiver uses ten poles of i-f filtering and dual gate MOSFETS for superior selectivity and cross-mod rejection.

Because all components, including controls and heatsinks, are mounted right on the main PC board, construction is simplified and cost is reduced. The complete kit costs only $159.95. Cabinets, microphones, and crystals

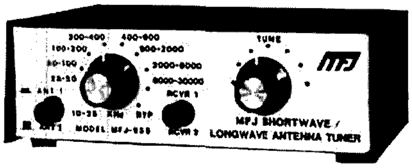
are readily available as options.

For further information, including a forty-page catalogue of all Hamtronics kits, contact Hamtronics, Inc., 65F Moul Rd., Hilton, New York 14468; telephone 716-392-9430.

MFJ-955 VLF/MW/SWL antenna

The new MFJ-955 VLF/MW/SWL preselecting antenna tuner greatly improves reception of 10-kHz through 30-MHz signals.

The MFJ-955 connects between your receiver and antenna. You can peak desired signals while rejecting interference and reducing overload, background noise, cross modulation, and inter-modulation. VLF signals come roaring in. Front panel switching allows push button selection of two antennas and two receivers.



The MFJ-955 sells for $59.95 (plus $4.00 shipping and handling), has a money back guarantee (less shipping and handling) and a one-year unconditional warranty.

For more information, contact MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, Mississippi 39762; telephone 800-647-1800.

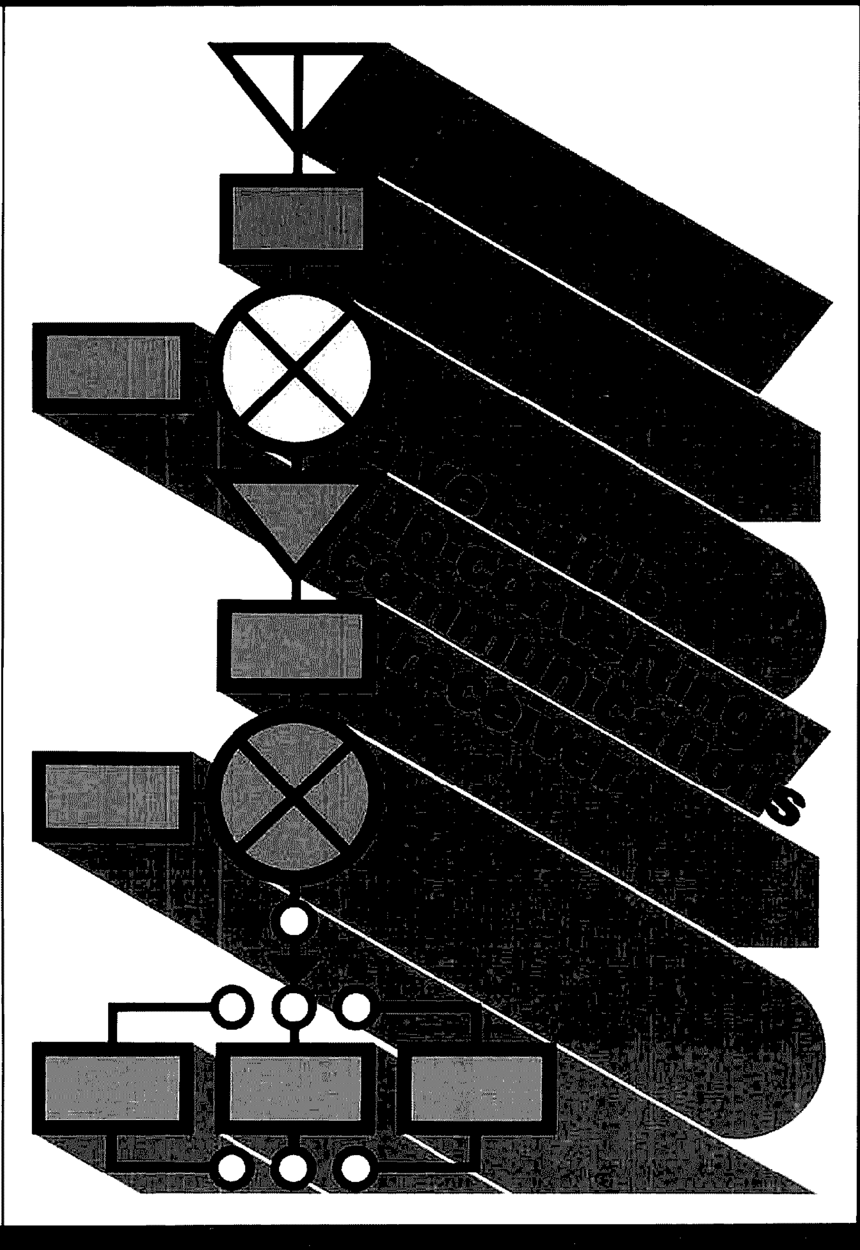
catalogs

Long known as an excellent source of coaxial cable and other products, Nemal Electronics has just released their latest catalog. Catalog B is chock full of interesting items for all electronic enthusiasts. They have a full line of coax cable and connectors for ham and TV use. Write today or check number 968 on Reader Service card for more information. Nemal Electronics, 3685 SW 80th St., Miami, Florida 33134.

JULY 1982 / $2.50

ham radio magazine

- review of 2-meter handhelds
- operation upgrade: part 8
- digital approach to odd splits: the ICOM IC-2AT
- VHF and UHF synthesizers



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Observation & Opinion

By now it's no secret to the American public that government services are being drastically cut by the Reagan administration's efforts to control government spending. It is also well known among knowledgeable Amateurs that those cuts have severely affected our friends at the Federal Communications Commission. The effects of the FCC's belt-tightening efforts are growing to the point where it's now considered likely that Commission administration of the Amateur exam program will be drastically curtailed if not eliminated altogether by the year's end.

Fortunately, timely provisions for filling this void are contained in the Communications Act rewrite bill originally introduced by Senator Barry Goldwater, K7UGA, and presently under consideration in the House of Representatives as HR 5008. Under the provisions of this bill, the FCC would be permitted to delegate both monitoring and exam administration responsibilities to the Amateur Radio community; this could, in theory, solve the problem. However, in its present form, the House Communications Act rewrite bill includes language which would prohibit anyone working for an organization involved in the production or distribution of any Amateur gear or Amateur Radio training materials from preparing or contributing to any Amateur Radio examination program.

Although this amendment does make sense — any organization that publishes training materials would be perceived by prospective Amateurs as having the "inside track" if it also were administering the exams — the amendment would also prevent the one organization in the country capable of taking over and handling a program of this magnitude from taking part in it. Whether that amendment will survive in the Congress, or how such potential conflicts of interest can be surmounted if it doesn't, remains to be seen. In the meantime, let's consider the potential benefits of an examination program administered by Amateurs.

Back in the good old days of Amateur Radio, the FCC was able to staff its field offices with well-qualified technical people, many themselves licensed Amateurs. These were the people who gave you the exam, and when they said you'd passed you knew you'd earned your license! Today, although the FCC still has many highly qualified people on its staff, these people are much too valuable to be looking over the shoulders of would-be Amateurs sweating over their exams. Exams are administered by clerical help, which is why there's no longer a CW sending test (who'd listen?), and why the CW receiving test is fill-in-the-blank and written exams are "multiple guess." At the same time there are well-founded fears that the proliferation of so-called cheat books — exam study guides that are nothing more than lists of the exact questions and answers out of the FCC's current exams — are creating a generation of Amateur appliance operators with no real knowledge of radio or electronic theory.

If Amateurs are going to take over exam administration (and it seems certain that they are), we as Amateurs have a golden opportunity to restore integrity to a program that's been seriously eroded in recent years. We've got an opportunity to break away from the simplistic multiple choice exam and go in new and innovative directions in the testing of new Amateurs. We could bring back essay-type questions, reinstitute the CW sending test, and even go to an interview exam where an applicant would discuss specified exam topics with a panel, which would then decide whether the applicant was ready either to become an Amateur or to upgrade. There is truly no end to the possibilities!

It is a golden opportunity, and whether we're prepared for it or not we're going to have to be ready with something — and very soon. Let's discuss it with other Amateurs, particularly those involved in licensing classes, and ask our League directors what they are doing about it in Newington. Like it or not, we're soon going to be in the exam business. We'd better be prepared!

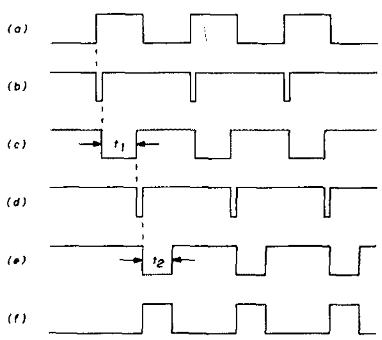
Joseph Schroeder, W9JUV

comments

Woodpecker blanker

Dear HR:

"Blanking the Woodpecker, Part Two: A Practical Circuit" by David Nicholls, February, 1982, *ham radio*, is an excellent article. Nicholls writes in a clear manner, and it is exciting to see a high-performance blanker built around three CMOS chips.



The timing diagram (**fig. 6**) is confusing, however, in that it depicts waveforms (b) and (d) occurring prior to the signals from which they are derived, waveforms (a) and (c), respectively. I am enclosing a corrected timing diagram. It's really a minor error.

Robert K. Zimmerman, NP4B
Arecibo, Puerto Rico

IC2AT power supply

Dear HR:

I had decided to design a mobile power supply for my IC2AT handheld 2-meter transceiver. I started reading the article by Gil Weiss, WB3JJF, (February *ham radio*) and decided not to design the power supply. After looking into the article more thoroughly I discovered a mistake.

The last sentence in the first paragraph under **construction** says, "If a spike greater than 12 volts should occur, the zener will shunt the circuit to ground and blow the fuse." My analysis is that the circuit does not perform in that manner. I figure the circuit will have 12 volts at the V_{out} if the zener is fast enough to go into regulation when the spike occurs and before the spike disappears. It is very possible the fuse will not blow.

The author could use a crowbar circuit using an SCR and set it to a threshold point to short and blow the fuse if spikes should occur.

Henry R. Leggette, WB4MNW
Memphis, Tennessee

I am providing the following in response to Mr. Leggette's questions concerning the circuit performance of the fuse and zener diode relative to high voltage spike protection.

This arrangement has been in print in several ham radio publications in similar circuits for various HT applications and is recommended by at least one major manufacturer of mobile equipment. I have discussed and questioned the circuit with other hams, including electrical engineers, and have gotten a variety of responses. The zener will conduct and blow the fuse, but for a very short period of time the spike does appear at the regulator output and, in my opinion, could damage a rig. The problem here is that most hams, including myself, do not have the sophisticated test equipment necessary to analyze this type of circuit performance where short-time-duration measurements become critical.

My prototype unit contained the zener protection for insurance, as shown in the article, but I have built subsequent units without the diode and they have been functioning fine. Transient voltage spikes in mobile operation can be best avoided by (1) wiring the regulator or equipment directly to the car battery, which provides natural surge suppression, and (2) shutting down the equipment when starting the vehicle since this is when spikes usually occur. Additionally, with all of the mobile gear in operation the instances of voltage spike or surge damage appears to be quite rare.

Although crowbar circuits are normally associated with ac power supplies, it appears that an SCR circuit could be used here, but the same question arises regarding potential damage by the spike in the few nanoseconds required to trip the SCR.

Any light that can be shed on this topic by other readers would be appreciated.

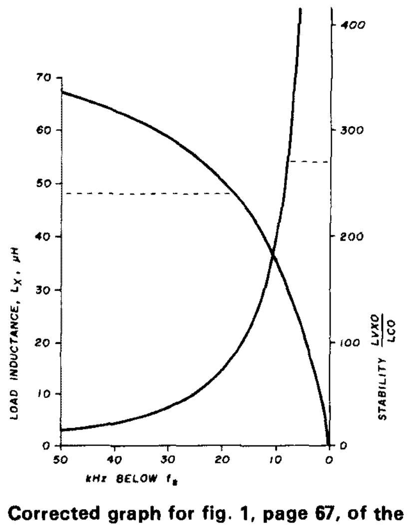
Gil Weiss, WB3JJF
Bensalem, Pennsylvania

phantom-coil VXO

Dear HR:

In my article (page 66 of the January issue), I failed to see that one of my marbles was nicked until after it was out of the bag.

While the curves of **fig. 1** are of the right general shape, both are too inaccurate to use for design purposes. Anyone reading the design example, page 68, must wonder where the numbers are coming from. Below is a copy of the correct graphs for **fig. 1**:



Corrected graph for fig. 1, page 67, of the January, 1982, issue. (HC6/U crystal, 40-meter LVXO. C_o = 6 pF; r = 250.**)**

Additionally, I've noticed that after a year of operation the oscillator would occasionally fail to start. The cure was to substitute the RCA 3N212 for Q1. This transistor has a much larger g_m, and should take care of the problem indefinitely.

Frank Noble, W3MT
Bethesda, Maryland

presstop

THE FCC HAS EXTENDED THE COMMENTARY CUTOFF DATE ON P.R. DOCKET 82-83 to August 16th. Docket 82-83 is the twin bill that proposes expanding U.S. 20-meter phone privileges to 14.150 MHz, and also requests input from Amateurs regarding phone expansion on other bands and incentives toward license upgrading. The ARRL had requested an extension to permit Amateurs time to read the full text of the proposal prior to filing comments. The text appears in the May issue of QST magazine, and the League asks that Amateurs read it and then convey their views to the ARRL Plans and Programs Committee, their Division Director and the FCC.

A CLAIM OF TEN CLEAR REPEATER AND EIGHTEEN SIMPLEX CHANNELS on 220 MHz, plus similar clear channels on 10, 6, 2, and 3/4 meters is being made by a contingent of Mexican Amateurs attending two recent meetings of the 220 SMA of Southern California. According to their spokesman, Amateur VHF/UHF repeater operation in Mexico has been directed by their government onto specific channel pairs as outlined in a reputedly formal agreement between Mexico, Canada, and the United States. The Mexicans claim they must move to these channel pairs shortly or face the confiscation of their repeater stations. Also, they state that the agreement calls for the channels to be kept totally void of U.S. operation for 150 miles from the border. WLR made an extensive check with the FCC and the State Department in Washington and the Canadian Department of Communications, in parallel with a similar investigation by the 220 SMA, and could find no evidence that such an agreement between any of the three governments has ever been negotiated. (The State Department did say that it was possible such an agreement was worked out by another Agency, and that they might not yet have been advised of any formal agreements either pending or reached.) The Mexicans, however, have provided 220 SMA with partial documentation from their government that there is such an agreement, and that all parties are expected to abide by it. As to the eighteen simplex channels, the Mexican Amateurs claim that these are also included in the accord, along with similar allocations elsewhere in the VHF/UHF spectrum.

AMATEUR RADIO'S PARTICIPATION IN THE 1984 OLYMPIC GAMES will be organized by a committee operating under the auspices of the Los Angeles Area Council of Radio Clubs. The League's Southwest Division Director, Jay Holladay, W6EJJ, announced formation of the committee, which is to be headed by Tom Rothwell, K6ZT, and will include W6ABW, WB6UIA, W6ZH, WB6ZEB, N2YQ, and Jay as members. The committee will oversee every aspect of Amateur Radio's involvement in and support of the '84 games. Amateurs from outside the Los Angeles area who are planning to attend the Olympics and who might want to take part in what now appears may become a massive communications effort are advised to contact Director Holladay. Due to the logistics of the Games and the large area to be covered, the help of a large number of Radio Amateurs will be needed.

THE TRANSMITTERS CAUSING INTERFERENCE in the 440-MHz region, referred to in the April issue of PRESSTOP, have been tentatively identified as a type of navigational aid called Syledis. Syledis is a medium-range positioning system that operates between 420 and 450 MHz. Syledis is described as "an along-shore navigation system with the accuracy of the best radio-positioning systems."

A NEW RUSSIAN AMATEUR SATELLITE was put into orbit in May when two Cosmonauts pushed the 62-pound Iskra 2 through the airlock of their Solyut 7 spacecraft. Tass reported the communications satellite, believed to translate signals from 15 to 10 meters, was created with the help of "young scientists and Amateur Radio enthusiasts" from the U.S.S.R. and several of its allies. This is probably the first working satellite put into orbit from a manned spacecraft.

H.R. 5008 IS REPORTEDLY OUT OF THE HOUSE TELECOMMUNICATIONS SUBCOMMITTEE virtually intact. The House version of Senator Goldwater's FCC revision bill (S-929) permits the Commission to set minimum RFI susceptibility standards for consumer electronic products. After going through the Committee to the full House for approval, it must be reconciled with the Senate version before going to President Reagan for his signature. Strong opposition to this provision is expected from the powerful EIA lobby.

A SECRET AMATEUR RADIO STATION MAY BE OPERATING IN THE FALKLAND ISLANDS. Although the Argentine military ordered all ham gear turned over to them in April, Gary Jordan, WA6TKT, listened to a QSO signing a VP8 prefix claiming to be from that area. We have been unable to confirm whether or not the station was legitimate.

ULRICH L. ROHDE, president of Rohde & Schwarz Sales Co., Inc. has announced his resignation effective June 30, 1982. He will pursue career goals in the fields of consulting and education. Dr. Rohde has been a frequent contributor to ham radio, and we wish him the best of luck.

A NEW HOUR-LONG AMATEUR RADIO TV PROGRAM is being aired every Sunday in New York City. Named "Network Two New York," the show is produced by Larry Horn, N2NY, and is carried live on cable channel D at 2:00 PM. Long range plans call for this program to be made available nationwide via satellite. Contact N2NY at 415 E. 80th St., New York City for more details.

versatile communications receiver

An up-converting design featuring a synthesized LO and digital readout

The trend in communications receivers in recent years has been toward up-converting superheterodynes with some sort of synthesized local oscillator and a digital readout. Several designs have been presented in the Amateur literature, and many units of commercial equipment are using the technique. The up-converting receiver can offer excellent performance but has been heretofore nearly impossible for the Amateur to build because of the difficulty in obtaining parts. In this design, great care has been taken to use parts that are available as catalogue items from manufacturers or from surplus sources. The design is adjustable to use parts that are available.

the up-converting technique

For those unfamiliar with the up-converting receiver, the name is derived from the fact that the first i-f is above the highest frequency tuned by the receiver. Thus, all input frequencies are converted up in frequency to the first i-f. For a receiver covering all of the high-frequency Amateur bands, this intermediate frequency is around 30 MHz or even higher. Since the image of a superheterodyne receiver is separated from the desired signal by twice the i-f, a high-fre-

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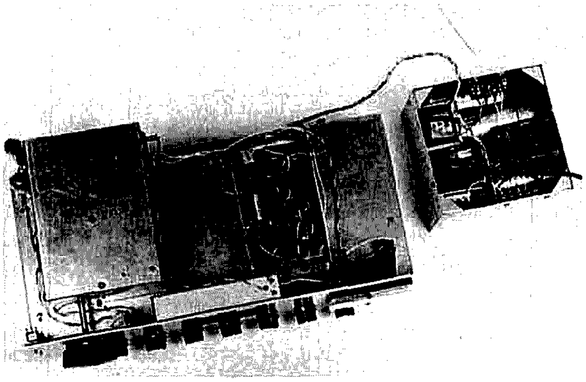
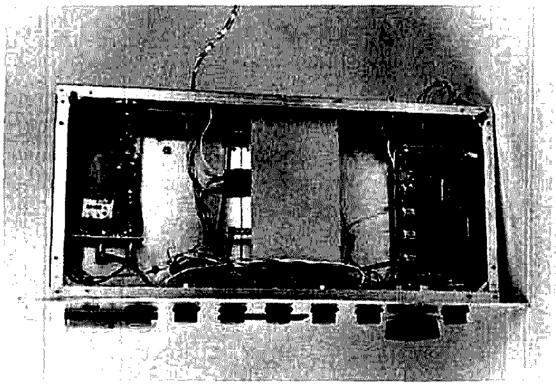


Top view of the receiver. The large box to the left is the VFO assembly, while the smaller box with cover removed is the synthesizer. Power supply is at far right.



Underneath the receiver. The box in the center with the cover attached is the second mixer. The front-end module is to the far left and the i-f amplifier is at the far right (covers removed).

quency receiver covering 0 to 30 MHz with an i-f of 30 MHz or greater would have an image band from more than 60 MHz to above 90 MHz. A lowpass filter is all that is required to remove these image frequencies.

Earlier and more conventional superheterodyne designs required a bandpass filter that had to be tuned with the local oscillator or "tracked" with the tuning control. For digitally controlled or synthesized receivers this is not a desirable characteristic. The lowpass filter in the up-converting receiver is fixed for the entire range of frequencies covered by the receiver.

From the simple description, it would appear that the up-converting receiver would be easy to build and a great beginner's receiver. Unfortunately, there are some problems unique to the receiver that require some specialized components.

First, the frequency of the first i-f, being greater than 30 MHz, makes it impossible to achieve the narrow selectivity required for CW or SSB reception at the first i-f. Therefore, a second conversion is required to reduce the i-f to a frequency where narrow crystal or mechanical filters can be used. The up-converting high-frequency communications receiver almost always uses dual or triple conversion. Secondly, the local-oscillator frequency is also very high and requires some form of crystal-controlled stabilization, such as a frequency synthesizer. Thirdly, since a lowpass filter is used preceding the mixer, the range of input signals fed to the mixer is very great, which increases the chances of harmful second- and third-order intermodulation. No rf amplifier is used and a good quality mixer, such as a double balanced diode mixer, reduces the generation of mixer distortion products. The application of modern components and techniques can easily control the disadvantages of the up-converting receiver.

overall receiver scheme

Fig. 1 shows the block diagram of the up-converting receiver excluding the power supply. The signal from the antenna is first passed through the 30-MHz lowpass filter to remove the image frequencies, which in this case are above 150 MHz. The double-balanced mixer provides the first conversion, using the output of the synthesizer as the local oscillator. This is the only local oscillator that is variable, and all receiver tuning is done with the synthesizer. The output of the mixer feeds the first i-f amplifier without any selectivity. Since the entire band of input frequencies is present at the mixer and the first i-f amplifier, these two circuits will have more influence over the dynamic range of the receiver than any other section. The 75-MHz first i-f filter is immediately after the first i-f amplifier and feeds the second mixer. Since the bandwidth of a 75-MHz filter is on the order of 20 to 40 kHz, there is a chance of intermodulation being generated in the second mixer, although not nearly as great as in the first mixer. In addition, there is a possibility of having some gain from the antenna to the input of the second mixer. Therefore, for signals closer than about 20 kHz, the dynamic range of the receiver is dependent on the second mixer.

The i-f filters immediately follow the second mixer, and the frequency of the second local oscillator will be determined by the center frequency of the filters used. The majority of the receiver's gain is obtained at the second i-f and is divided into two sections. The i-f preamplifier provides about 10 dB or so of gain and does not have AGC action. The main purpose of

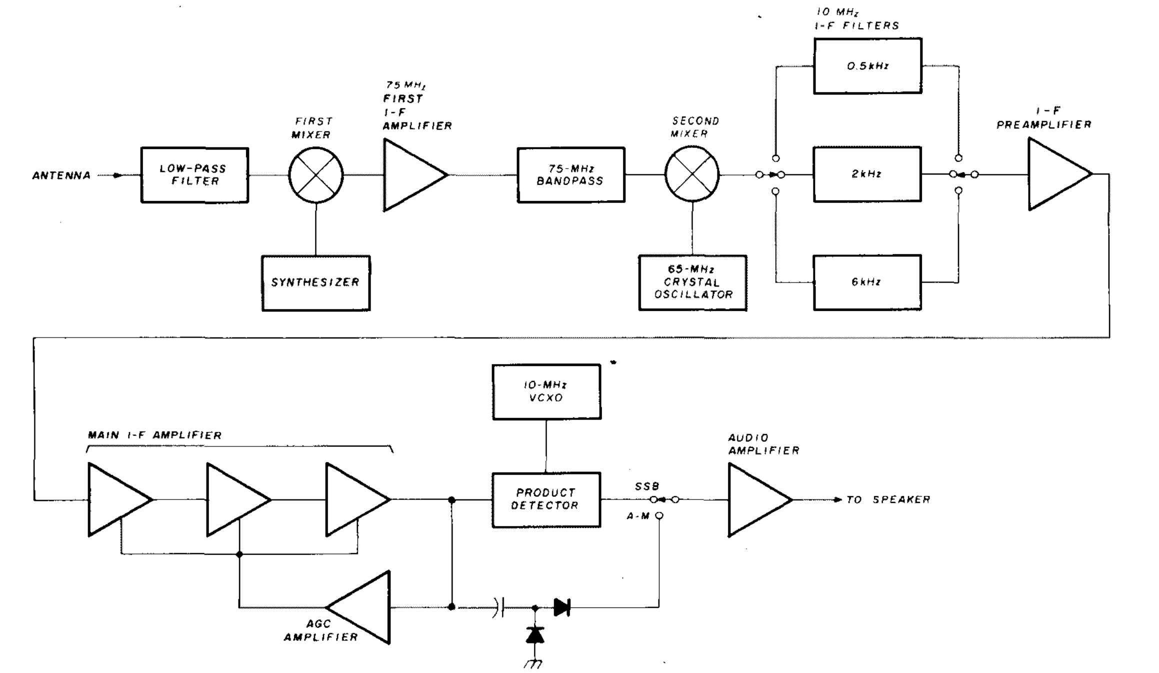


fig. 1. Block diagram of the up-converting receiver excluding power supply and audio amplifier. Lowpass filter preceding the mixer removes image frequencies, which are above 150 MHz. Second mixer is a dual-gate FET circuit, which obtains its LO signal from a fifth-overtone crystal oscillator. Each of the three i-f amplifiers provides about 20 dB gain.

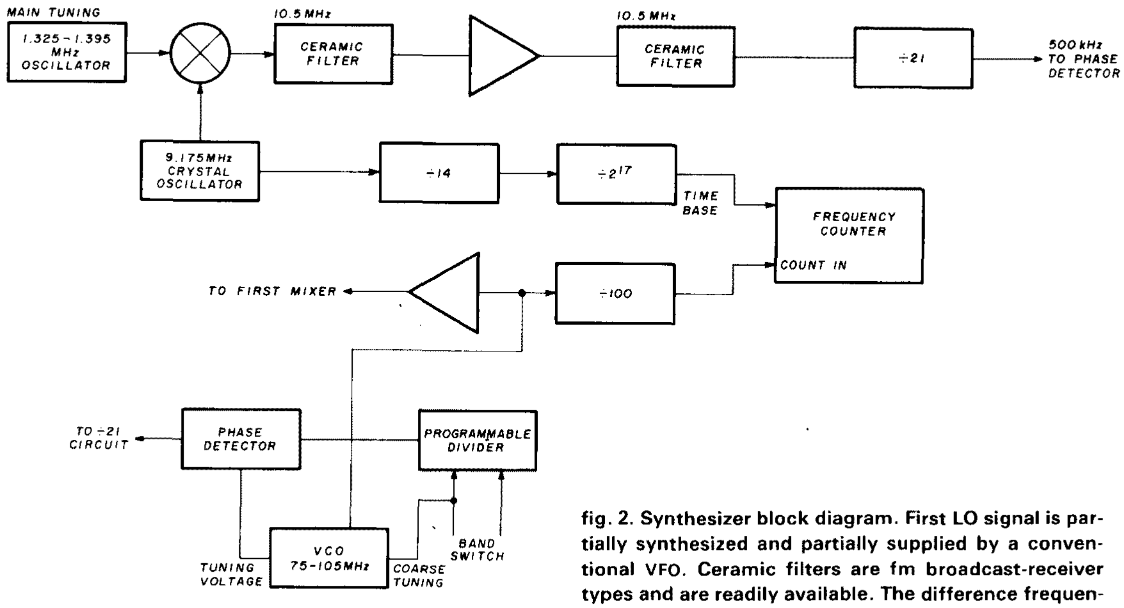


fig. 2. Synthesizer block diagram. First LO signal is partially synthesized and partially supplied by a conventional VFO. Ceramic filters are fm broadcast-receiver types and are readily available. The difference frequency between the VFO and crystal oscillator controls a phase-locked-loop LO, which operates between 75 and 105 MHz.

this stage is to match the impedance of the filters to 50 ohms to drive the cable that connects the i-f preamplifier to the main i-f amplifier. Three dual-gate FET i-f amplifiers are used for the majority of the i-f gain and gain-control action. A simple carrier-operated AGC system is used, while both a diode detector and a product detector are supplied for SSB/CW/RTTY or a-m detection. The BFO is a voltage-tuned crystal oscillator that is pulled far enough in frequency to cover both upper and lower sidebands. The actual frequency of the crystal will depend on the center frequency of the filters used. A low-power audio amplifier constructed from a single IC is all that is required to drive a small loudspeaker.

The stability, dial accuracy, tuning rate, and, to some extent, the dynamic range of a receiver is a function of the local oscillator signal. In this receiver, the first local oscillator signal is the controlling factor and is supplied from a frequency synthesizer as shown in the block diagram of fig. 2. The local oscillator signal is partially synthesized and partially supplied from a conventional VFO. I wanted to obtain the infinite resolution that only a variable oscillator can achieve, while obtaining the frequency accuracy and stability that only a phase-locked loop can achieve — all of this with readily available parts. The technique chosen was to heterodyne a crystal oscillator with a much lower frequency VFO and use the difference frequency to control a phase-locked-loop local oscillator between 75 and 105 MHz.

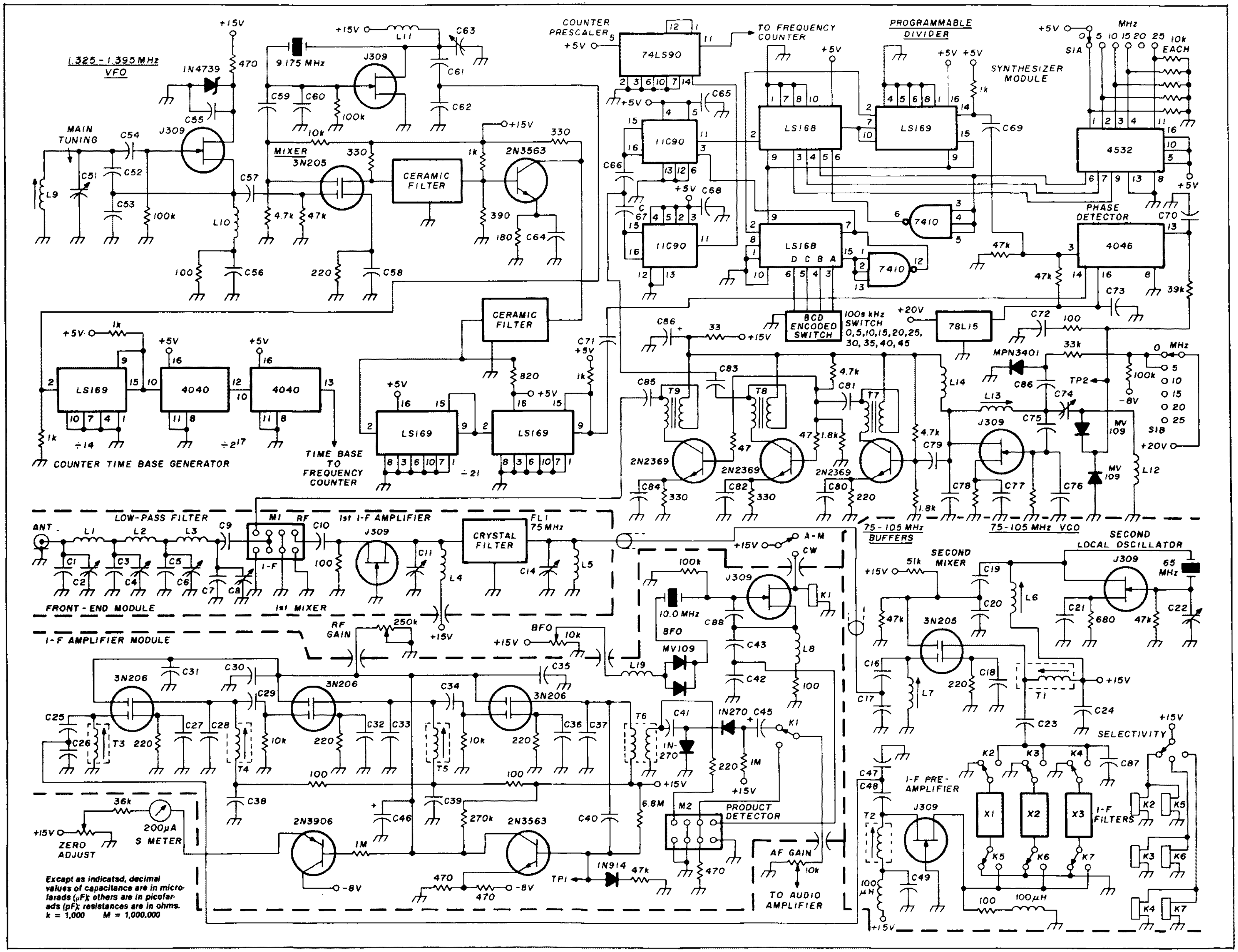
Referring to fig. 2, a VFO operating between 1.325 and 1.395 MHz is heterodyned with a crystal oscillator operating at 9.175 MHz. The difference frequency, which covers the range between 10.5 and 10.57 MHz, is filtered with ceramic filters and divided down to 500 kHz with standard TTL logic. It is important that the difference frequency be carefully filtered for low-noise performance. The ceramic filters are intended for use in fm broadcast receivers and are readily available.

The nominal center frequency of ceramic filters varies considerably when they are manufactured and are color coded into selected groups. The filter used in the synthesizer has a center frequency of 10.64 MHz and is coded with a black dot by most manufacturers of these filters. The passband of these filters is sufficiently wide to pass the desired 10.5-MHz signal but narrow enough to reject the undesired 7.85 MHz image. The 9.175-MHz crystal is divided down to 5 Hz for use as a time base for the frequency counter. The 500-kHz output from the digital divider is used as a reference for a phase-locked loop. A 75- to 105-MHz oscillator is phase locked in 500-kHz steps to this reference using standard pulse swallowing techniques. Since the frequency of the 500-kHz reference is slightly variable as controlled by the VFO, the frequency range between the even 500-kHz steps can be covered.

There is one significant disadvantage to this method of local oscillator generation; the tuning rate for the 500-kHz bands is different. For example, if the VFO allows the receiver to be tuned 500 kHz on the lowest-frequency band, (0-500 kHz) the range on the highest band would be 700 kHz. Since the actual fre-

fig. 3. Schematic diagram (page 16) of the up-converting receiver. Circuit is composed of six modules, all of which are built into shielded boxes. X1-X3 are 10-MHz monolithic selectivity filters, but the more common 10.7-MHz filters may be used by changing the second LO crystal frequency to 64.3 MHz for a 10.7-MHz i-f. Parts list is below.

C1,C3,C5,C7	*75-pF mica 50 V*
C2,C4,C6,C8 C22,C63,C74	*7-35 pF ceramic trimmer*
C9,C72,C73	*0.1-μF ceramic 50 V*
C10,C11,C14,C15,C38, C39,C41,C49,C54,C56, C57,C58,C59,C64,C65, C68,C69	*0.01-μF ceramic 50 V*
C17,C20,C42	*220-pF mica 50 volt*
C16	*33-pF mica 50 volt*
C18,C21,C26,C27,C29, C30,C32,C34,C35,C36, C47,C66,C67,C70,C80, C81,C82,C83,C84,C85, C87	*1000-pF ceramic 50 V*
C23,C25,C28,C33, C37,C40,C48,C60	*56-pF mica 50 V*
C19,C43,C44,C88	*39-pF mica 50 V*
C45,C86	*10-μF 25 V*
C46	*3.3-μF 25 V tantalum*
C51	*20-pF gear driven variable (see text)*
C52,C53,	*330-pF mica 50 V*
C86	*10-pF mica*
C75,C76	*15-pF mica 50 V*
C78	*39-pF mica 50 V*
C79	*2.2-pF ceramic NPO*
FL1	*Piezo Technology 4171F 4-pole crystal filter*
L1,L3	*13 turns on Micrometals T50-10 core No. 26 wire*
L2	*14 turns on Micrometals T50-10 core No. 26 wire*
L4,L5	*14 turns on Micrometals T20-10 No. 32 wire*
L6,L7	*1-μH slug-tuned coil*
L8,L10,L15, L17,L18	*330-μF rf choke*
L9	*75-μH slug-tuned coil*
L11	*6.8-μH rf choke*
L12,L13	*0.22-μH*
L14	*2.2-μH rf choke*
L16	*5.6-μH rf choke*
T1,T2,T3, T4,T5,T6	*10.7-MHz i-f coil, 4.5 μH nominal (see text)*
T7,T8,T9	*7 turns primary and secondary bifilar wound on an Indiana General CF-101 ferrite core*
M1,M2	*double-balanced mixers (Mini Circuits Labs SRA-1)*
X1,X2,X3	*i-f selectivity filters (see text)*



Except as indicated, decimal values of capacitance are in microfarads (µF); others are in picofarads (pF); resistances are in ohms. k = 1,000 M = 1,000,000

quency is read by a frequency counter, the display would not be in error, but the tuning rate would change accordingly. This problem was simply solved by using a tuning rate slightly slower than optimum at the lowest frequency and just a bit fast at the highest range and using a very smooth tuning capacitor. With this arrangement, the tuning rate difference is hardly noticeable and certainly not objectionable. Because the phase-locked loop reference frequency is 500 kHz, and since the actual tuning is performed with a VFO, the loop is easy to design and gives excellent performance. Receiver stability depends on the stability of the VFO, which must be carefully designed. On the highest frequency band, the frequency drift of the VFO is multiplied by a factor of ten relative to the received frequency; but because the VFO operates at only 1.3 MHz, it is not difficult to reduce the frequency drift to an acceptable level.

the circuit

Implementing the block diagram into a working receiver was done with great care to produce a receiver that could be constructed by the Amateur with parts available everywhere. The schematic, **fig. 3**, shows the majority of the receiver. The power supply and audio amplifier are diagrammed in **fig. 4**. A detailed

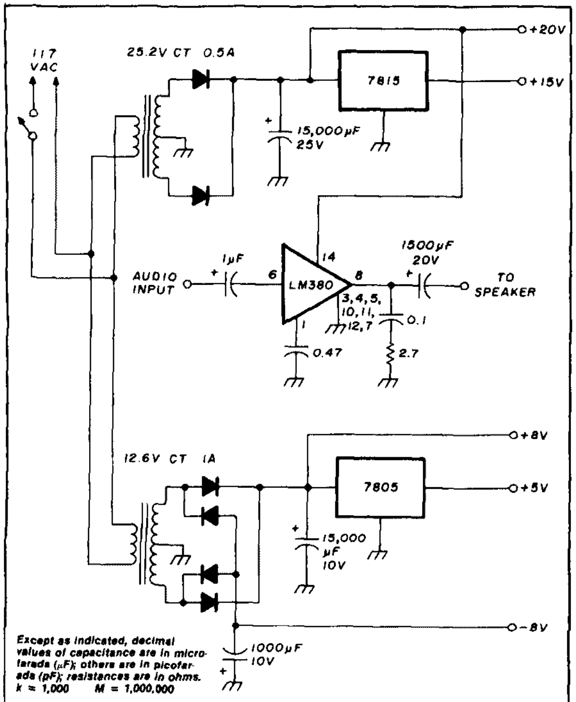


fig. 4. Power-supply and audio-amplifier schematic diagram. This module is built into a separate box away from the receiver circuits to isolate the largest source of heat and to prevent frequency instability.

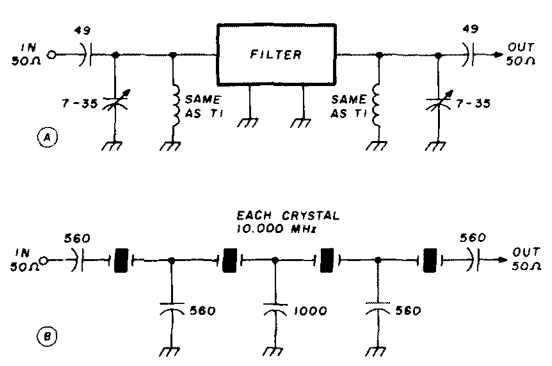


fig. 5. Matching networks for the i-f filters. The network for the monolithic filters is shown at A. Values of components are determined by the filters used (see text). The 500-Hz CW filter, B, is made from four fundamental-mode crystals, which are calibrated for series-mode operation and have a series resistance of less than 30 ohms.

schematic of the selectivity filters is shown in **fig. 5**, and the frequency counter in **fig. 6**.

Front-end components. The input signal from the antenna is first passed through a seven-pole lowpass filter with a cut-off frequency of about 30 MHz. Toroid inductors are used to provide a high ultimate rejection to signals outside of the passband. Also, variable capacitors are used to tune the filter to exactly the proper passband shape. The first mixer, which immediately follows the lowpass filter, is a standard-level prepackaged mixer. In this receiver the mixer port called "I-F" is used for the input rf signal. This is because the lowest frequency at which the receiver is capable of operating is about 10 kHz, and the rf port on most mixers cannot operate at this low frequency. The remaining two ports, the LO and rf ports, operate above 75 MHz and do not suffer from this problem. The output of the mixer feeds the 75-MHz i-f amplifier, a grounded-gate amplifier without tuning on the input, which provides a good termination for the balanced mixer. The output of the first i-f amplifier is matched to the 75-MHz monolithic crystal filter. The overall gain from the antenna to the output of the 75-MHz filter is between zero and 3 dB.

Second mixer and i-f selectivity section. Since there is essentially no overall gain from the antenna to the input of the second mixer, I decided that the second mixer should have some gain, and the dual-gate FET circuit shown in **fig. 3** was chosen. A simple fifth-overtone crystal oscillator was used for the LO for the second conversion from 75 MHz to 10.0 MHz. About 15 dB of gain is available from the mixer before the signal is fed into the i-f filters.

Switching of the i-f filters is done with relays for

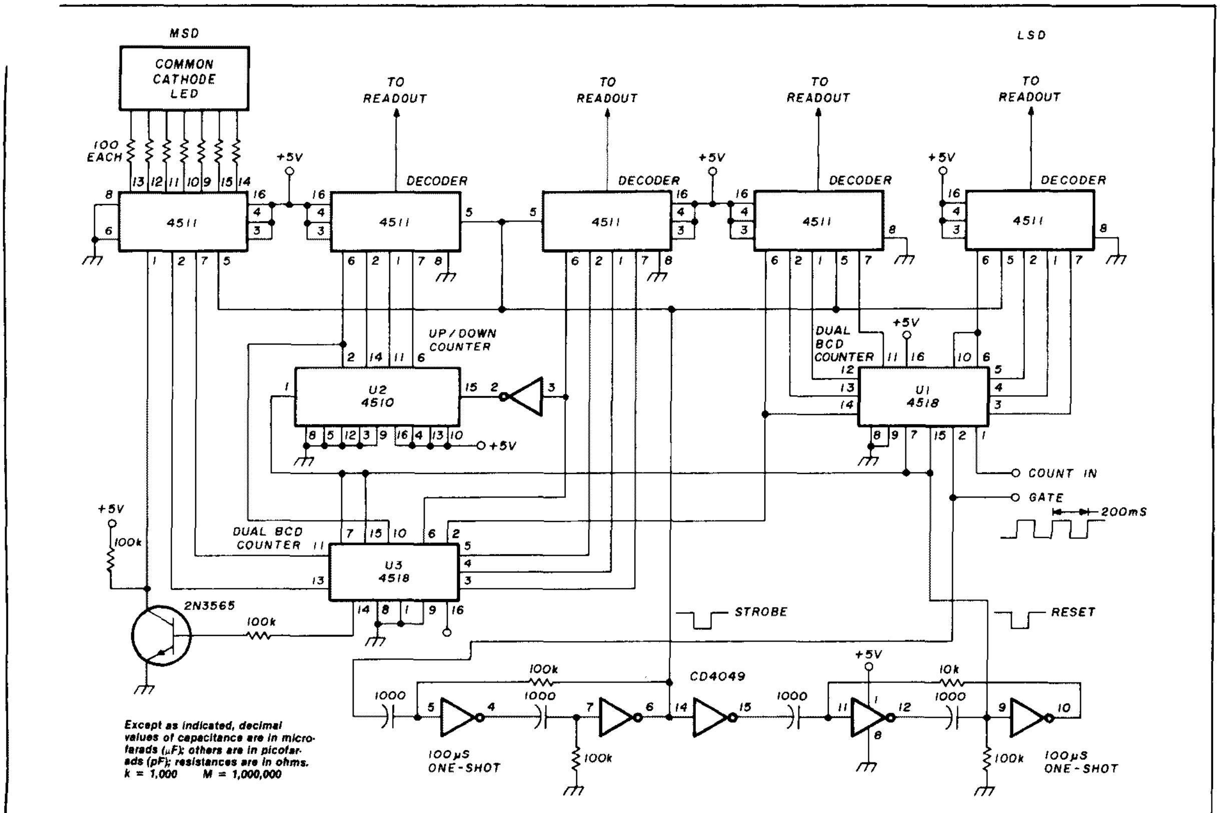


fig. 6. Schematic diagram of the frequency-counter section. This circuit automatically subtracts the first i-f from the counted frequency.

several good reasons. First, the relays allow for simple front-panel switch connections. The selectivity switch has only three wires that carry only dc. Second, it simplifies the layout of the receiver, because the selectivity switch can be mounted anywhere relative to the filters. And, finally, the shielded sealed relays allow for a very high ultimate attenuation by reducing the amount of feedthrough around the filters. PIN diodes would be a modern substitute, but a good supply of sealed relays were available to me. The choice of the second i-f was also dictated by what was available. The unusual 10.0-MHz i-f was chosen to make use of a set of filters for that frequency. Nine MHz or 10.7 MHz would be more common frequencies and may be used by changing the second LO crystal to 64.3 MHz for a 10.7-MHz i-f or 66 MHz for a 9-MHz.

The blocks X1, X2, and X3 in **fig. 3** represent the filters and circuitry to match them to 50 ohms. **Fig. 5** shows the matching circuitry for the 10.0-MHz monolithic filters I used. The 10-MHz filters will not be readily available, but standard 10.7-MHz filters use a very similar matching network. Most filter manufacturers provide a test circuit to match their filters to 50 ohms for evaluation, and these circuits will work in the receiver. The 500-Hz filter, also shown in **fig. 5**, is constructed from four fundamental-mode crystals. These crystals are calibrated for series mode and should have a series resistance less than 30 ohms, which is typical for most good-quality crystals. The output of the i-f filter is terminated with a grounded-gate FET preamplifier, which feeds the main i-f amplifier through a 50-ohm line. The overall gain from the antenna to the output of the second mixer module is about 20 dB.

I-f amplifier demodulator. The majority of the receiver gain is obtained at 10.0 MHz in the i-f amplifier module through three dual-gate FET amplifiers. Each stage provides about 20 dB of gain and at least 30 dB of AGC cutback per stage. The output of each amplifier is tuned to reduce the noise level of the i-f system. The AGC system is a carrier-operated type using a transistor as a detector, and also provides additional gain in the AGC loop. The AGC hold capacitor, C46 is discharged rapidly through the collector of the AGC transistor and charged slowly through the 270k resis-

tor connected to the power supply. The rf gain control determines the maximum gain of the receiver but does not disable the AGC action. A buffer amplifier isolates the S-meter load from the AGC line.

The BFO for the product detector is a voltage-tuned crystal oscillator. A frequency variation of about 1.5 kHz either side of the nominal 10.0 MHz is achievable with the two paralleled varactors as shown. The audio output from either the product detector or the diode detector is selected by a relay, the coil of which is connected to the BFO power supply so that the audio is automatically switched from the diode detector to the product detector whenever the BFO is energized. Again, the availability of sealed relays was the driving force behind this arrangement.

Frequency counter. The actual received frequency of the receiver is the local oscillator frequency minus 75 MHz. Originally, a single chip counter was used to count and display only the last three digits of the frequency. A major problem with this counter was interference due to multiplexing of the readout digits. Noise was heard in the receiver on the lower frequencies. Since the receiver is capable of operating down to 10 kHz, the lower 100 kHz or so was practically useless.

A second counter was constructed, shown in **fig. 6**, without multiplexing the display. In addition, the entire frequency is displayed to the last kHz. U1, U2, and U3 (**fig. 6**) are binary-coded decimal counters making up the five-decade range required. U1 and U3 are conventional dual BCD counters, while U2 is a presettable counter. As in any conventional counter the input frequency is gated, and the resulting count is strobed into the displays. However, the counter is not reset to zero but to 0500, which effectively subtracts 5 MHz from the count. The additional 70 MHz is subtracted by wiring and inverting the data connections to the tens-of-MHz readout decoder input. Five sections of a hex inverter are used as a dual one-shot to provide the reset and strobe signals.

Synthesizer. Even though great efforts were taken to simplify the synthesizer, it is probably the most complex part of the receiver. Basically two separate units make up the synthesizer: the VFO module and the synthesizer module. Referring to **fig. 3**, the VFO is a standard Colpitts circuit operating from 1.325 to 1.395 MHz. The stability of the oscillator is ensured by using polystyrene and mica capacitors and providing a separate zener-regulated supply voltage. No buffer amplifiers are used since the VFO feeds the high input impedance of a dual-gate FET mixer circuit.

The second gate of the dual-gate FET mixer is fed from a 9.175-MHz Pierce oscillator. The drain of the mixer is terminated with 330 ohms and feeds a ceramic filter. A buffer amplifier feeds a second ceramic filter, which drives a TTL divide-by-21 circuit. The output of the divide by 21 is 500 kHz to 503 kHz for the synthesizer. In addition, the 9.175-MHz crystal oscillator frequency is divided by 1.835×10^6 to provide a 5-Hz reference for the frequency counter.

The synthesizer module contains the programmable divider, the VCO and the phase detector for the local oscillator. The VCO is a Vackar circuit that drives a buffer amplifier, which in turn drives two parallel amplifiers. One amplifier feeds the mixer and the other feeds two ECL counters. One ECL counter is a part of a divide-by-100 circuit for the frequency counter, while the other ECL counter is the dual module prescaler for the programmable divider. The mode counter is programmed by the 500-kHz bandswitch, which is a BCD-encoded switch and presets the inputs to the 74LS168 counter directly. The 5-MHz bandswitch programs the main counter through a priority encoder. In addition, the 5-MHz switch switches a fixed capacitor into the VCO at frequencies below 10 MHz.

construction

The receiver is constructed behind a standard 7-inch (18-cm) rack panel and is divided into seven modules. The following segments are built into shielded boxes: front end, second mixer, i-f amplifier, synthesizer, counter and VFO. The seventh module, the power supply, is built into a separate chassis to remove as much heat from the receiver as possible.

A 3 × 7 × 17 inch (7.6 × 18 × 43 cm) chassis is fastened to the rack panel by using the hardware from the front panel controls, and the shielded subassemblies are mounted to the top and inside of the chassis. Most of the front-panel controls pass only dc, so it is possible to place the switches anywhere that's convenient and run the wires any distance to the appropriate subassembly. It is important that all of the circuits be properly shielded. Feedthrough capacitors were used for power and low-frequency signal lines, and rf connectors and coaxial cables were used for all other signal lines. This is especially important for the digital subsystems, the counter, synthesizer and VFO.

Double-sided PC board stock was used for making all the rf circuits, while the digital circuits were constructed on universal DIP plugboard.

Front end. The front end module is constructed in a 5-1/2 × 3-1/8 × 1-1/4 inch (14 × 8 × 3 cm) box and contains the front-end lowpass filter, first mixer, first i-f amplifier, and the first i-f filter. The toroid inductors are fastened to the PC board with silicone

ɔer, and the filter is arranged in a straight line to ıinimize the amount of feedthrough at VHF. The double-balanced mixer can be practically any standard mixer available with a 7-dBm local oscillator requirement and is soldered directly to the PC board with its pins up. The first i-f amplifier is constructed close to the mixer and the 75-MHz filter.

Second mixer module. The second mixer is constructed in a 6 × 3-1/2 × 2 inch (15 × 9 × 5 cm) aluminum box. Enclosed in this box is the second mixer and local oscillator, all of the i-f filters, their switching and the i-f preamplifier. Shields are inserted between the filters to prevent feedthrough. Six relays do the job of switching the i-f filters and great care was taken not to allow the wires that connect the relay coils from passing near the input and output of the filters. This would allow signals to be passed along the wire and destroy the ultimate attenuation of the filter. One advantage of using the relay is that no switch shaft need pass from the front to the rear of the filter to provide this leakage path.

Tuned circuits at the second i-f are required. These were constructed from standard 10.7-MHz i-f coils with external capacitors. Since the i-f used in my receiver was 10.0 MHz, external capacitors were required to resonate the i-f transformers. If the i-f is 10.7 MHz, the standard i-f transformers will work well without any modification. If the second i-f is 9.0 MHz, the i-f transformers will have to be further padded with external capacitors. Some sort of shielded inductor is required for the tuned circuit to prevent instabilities and signal leakage. These tuned circuits are used at the output of the second mixer, in the two monolithic filter matching networks, and the output of the i-f preamplifier.

I-f amplifier module. The i-f amplifier box is 5-1/2 × 3-1/8 × 1-1/4 inches (14 × 8 × 3 cm) and contains the three i-f amplifiers, BFO, and product detector. The same i-f transformers used throughout the receiver are used as interstage coupling in the i-f amplifier. In addition, shielding between the i-f stages is required to prevent oscillations. Most important, the shielding between the BFO and the i-f amplifier must be complete, otherwise energy from the BFO will enter the i-f amplifier and cause undesirable cutbacks in the AGC system.

The AGC is a carrier-operated system that is used on both a-m and SSB/CW and can be degraded by BFO leakage. In my receiver, it was possible by experimenting with shield locations to reduce the BFO leakage to a point where the S-meter will hardly move when switching the receiver from a-m to SSB. If the cutback is slight the degradation will go unnoticed, but if the cutback is several S-units, the receiver will not be able to copy weak signals.

The BFO uses a crystal oscillator that is tuned with a varactor diode. The BFO frequency as a function of the shaft rotation of the potentiometer is not linear, and only part of the rotation is used to set the BFO frequency as can be seen from the photograph of the front panel.

VFO module. The VFO module is housed in a 5 × 7 × 3-inch (13 × 18 × 7.6-cm) aluminum box and is mounted on top of the chassis with the tuning shaft protruding from the front panel. The capacitor used will determine the design of the actual VFO circuit. The capacitor used on my receiver was obtained surplus and had an attached motor drive. The total number of turns from end to end was 50, which explains the necessity for the motor. The size and position of the VFO box, as well as the design of the VFO, will be determined by the capacitor. The 9.175-MHz crystal oscillator, mixer, 10.5-MHz amplifier, divide-by-21 circuit and the time-base divider for the frequency counter are all contained in the VFO module. It is important not to allow any of the signals to leak from the box as they will cause spurious responses. All connections to the box are made through either feedthrough capacitors or coaxial cables.

Synthesizer and frequency counter. A 6 × 3-1/2 × 2-inch (15 × 9 × 5-cm) aluminum box encloses the synthesizer, which contains the programmable divider and phase detector for the first local oscillator; the VCO; and the divide-by-100 prescaler for the frequency counter. The number of connections into and out of the module is large, and they should be bypassed whenever possible to prevent radiation of spurious signals.

The rf output for the local oscillator is made through a 50-ohm cable, and the 500-kHz reference connection from the VFO box is made with shielded cable. The band switches, which are actually a part of the synthesizer, are mounted on the front panel.

The frequency counter is constructed in a 5-1/2 × 3-1/8 × 1-1/4-inch (14 × 8 × 3-cm) aluminum box and is mounted on the front panel with the readouts exposed through a cutout. In my receiver, the first two LED readouts (the MHz and tens of MHz) are red, while the remaining three readouts are yellow. This makes the dial easy to read and improves the esthetics.

Power supply and chassis. The power supply is mounted in a separate box away from the rest of the receiver to remove the largest source of heat and prevent instability. The regulators are mounted within the chassis to reduce ground loops. The audio amplifier is also mounted within the chassis, but away from the VFO. All the connections to the front panel controls are either dc signals or audio frequency,

which allows complete flexibility in the front panel layout and wiring. In fact, many of the functions of the receiver can be remotely programmed. A special scale was created for the S-meter. Instead of the conventional S-units and dB above S9, the signal strength meter was calibrated in microvolts. The meter was disassembled and the original meter markings sanded smooth with fine aluminum oxide paper. The face was painted a flat black, and new calibrations were applied using dry transfer letters. The recalibrated meter was then sprayed with a coat of clear lacquer. The front panel is painted white with all of the trim in black.

receiver alignment

The receiver should be aligned with a sweep generator and an oscilloscope. It is possible, however, to get a reasonable alignment with a CW signal generator and a voltmeter.

The first section to align is the input lowpass filter. The sweep generator output should be applied to the receiver's antenna jack and an rf detector placed at the output of the filter in lieu of the balanced mixer. Tune the filter so that it is as flat as possible with minimum loss. Additional alignment of the front-end subsystem is done after the synthesizer is operational.

The second mixer and local oscillator are aligned by feeding a 75-MHz sweep signal to the input while applying the rf detector to the output connector. Adjust the 65-MHz oscillator by tuning the slug while monitoring the gate voltage. Tune for maximum gate voltage while checking that the oscillator starts each time power is applied. Once the oscillator is operating, select the broadest i-f filter and tune T1 and T2 for maximum signal output. Then, tune the filter matching networks for the least passband ripple on each filter.

Many sweep generators will not have enough stability to sweep the filters accurately. If this is the case, the filters may be aligned using a CW generator manually swept across the filter frequency. Depending on the filters used, the gain of the second mixer module should be about 10 dB.

The i-f amplifier/detector module is aligned next using the sweep generator. No rf detector is required for the alignment of this stage, as the a-m detector may be used. The AGC is disabled by shorting TP1 to ground, and the i-f amplifier is tuned to the same center frequency as the i-f filters. A signal of only a few microvolts should be visible on the oscilloscope, so be sure to keep the level of the sweep generator low.

The frequency synthesizer may be aligned without the use of the sweep generator. Connect the synthesizer to the proper output of the VFO box and place both band switches to the 29.5-MHz band. The phase-locked loop should be locked, which is evident by monitoring the control voltage at point TP2. Adjust L13 for a control voltage of 14 volts. Place the band switch to zero MHz, and adjust C74 for a control voltage reading of 2 volts. Be sure that the synthesizer phase-locked loop locks on all bands from zero to 29.5 MHz. Also, turn the main tuning control and band switches to 30.0 MHz to be certain that the loop locks at the maximum frequency.

The remaining alignment of the front end will require the synthesizer to be connected to the first mixer. Apply an input sweep generator frequency anywhere from a few MHz to 30 MHz, and set the receiver band switches to the corresponding setting. Place the rf detector at the output of the front-end box, and adjust C11 and C14 for a symmetrical and flat response of the 75-MHz filter. The gain from the input to the output of the front-end box should be about 0 dB.

This completes the alignment of the receiver, and once all of the modules have been interconnected, the receiver should function.

If the receiver has been carefully constructed, there should be a minimum of birdies. Most notable is the 500 kHz VFO output, the crystal oscillator in the VFO box at 9.175 MHz, and the BFO at 10.00 MHz. Other spurious signals may appear, depending on the effectiveness of the shielding and filtering. Strong spurious signals not mentioned should be investigated to determine their source.

modifications and additions

Several modifications may be made to the receiver to enhance and improve its operation while retaining the basic form of the unit. Improvement in dynamic range can be obtained by replacing the standard-level double-balanced first mixer with a high-level unit, providing an increase in local-oscillator level. One very promising modification would be the substitution of an active balanced mixer such as the recently introduced SP-6440 from Plessey semiconductors. This chip has a third-order intercept of +30 dBm, which is hard to beat, even with a high-level diode mixer. It is also possible with the active mixer to obtain about 10 dB gain as opposed to the usual 6 dB loss, which results in an additional 16 dB gain. Using any sort of higher-level mixer, and certainly using an active mixer, would require that the second mixer be improved. At the very least, the second mixer could be changed to a double-balanced diode mixer, but this would seriously degrade the over-all gain of the receiver. If the active mixer is used in the front end, the additional gain of the front-end mixer can make up for the loss from substituting a diode mixer in the second mixer slot. The most elegant so-

lution would use the double-balanced active mixer in both locations and eliminate the first i-f amplifier.

Another possibility for modification is to change the first i-f. Although the 75-MHz filter is a catalogue item and is easy to interface with the frequency counter, the 75-MHz frequency is a bit higher than optimum. With the increase in up-converting receiver designs, crystal-filter manufacturers will no doubt be making filters in the 40-50 MHz range available for reasonable prices. One such possibility is a 45-MHz unit manufactured by Piezo Technology for fm communications equipment. It would be easy to rewire the tens-of-MHz digit in the frequency counter, change the second local-oscillator crystal, and to reprogram the divider in the synthesizer to cover 90-150. The only major disadvantage of the lower first i-f would be an increase in the tuning-rate problem. Two major advantages would occur: the lower i-f filter has a considerably narrower bandpass and would improve the intermodulation from close-in signals, and the frequency stability would be improved.

Some accessories have either been developed or are planned to be developed for the receiver that are not necessarily modifications to the basic receiver but allow for additional operating modes and conveniences. A frequency-lock circuit will be added to the VFO to provide extreme frequency stability. The frequency-lock circuit will allow the receiver to be phase locked to a crystal on any frequency tuned by the VFO. The frequency-lock circuit will be energized by pressing a lock push switch mounted near the tuning control and disabled by pressing an unlock switch. The electronics for the lock circuit will be installed inside of the receiver cabinet and consists of about seven integrated circuits.

An antenna tuner/preamplifier for use in the 100-kHz to 500-kHz range has been built to improve the performance of the receiver with short reactive antennas on the lower-frequency bands. The 50-ohm input of the receiver makes it difficult to obtain adequate signal strength below 500 kHz, but the tuner provides a method of tuning out the reactance and matching the antenna to the receiver's 50-ohm input.

The final and almost obvious accessory for the receiver is a matching transmitter. Such a device is planned, not as a stand-alone transmitter, but as a transceiving adapter. This adapter will contain a 75-MHz CW/SSB generator, mixer, and power amplifier. The adapter will use the synthesizer and frequency counter from the receiver for its local oscillator and frequency readout. Receiver incremental tuning must be added to the receiver, and this is most easily done by placing a varactor across C22 and tuning the varactor from the front panel of the transceiving adapter.

ham radio

design of the digital components of VHF and UHF synthesizers

A discussion of multimodulus prescalers for use with IC programmable dividers

The use of **digital frequency synthesis** is now common in commercially made transceivers for use on the VHF and UHF bands. This article discusses some aspects of the design of programmable counters for use in VHF and UHF synthesizers. It is illustrated by reference to the family of frequency synthesizers manufactured by Plessey Semiconductors, Ltd., and concludes with a description of a BASIC computer program that may be used to design frequency synthesizer dividers for use at VHF and UHF.

A basic frequency synthesizer is shown in **fig. 1**. It consists of a voltage-controlled oscillator (VCO), a programmable divider, a phase detector, a low-pass filter (LPF) and a stable reference-frequency source. The design of the VCO is the most critical part of the design process, closely followed by the design of the LPF. Attention must also be paid to isolating the VCO, by buffer amplifiers or otherwise, from both the output port and the input to the divider. These problems, however, are outside the scope of this article.

The action of the synthesizer is quite simple: the output from the VCO (which is the output signal of the synthesizer) is divided by n in the programmable divider and compared with the reference signal in the phase comparator. The output of the phase comparator controls the frequency of the VCO. The system is thus a phase-locked loop (PLL) acting to maintain the divider output in phase with the reference input. The VCO frequency is stabilized at n times the reference frequency (that is, $F_{out} = nF_{ref}$) where n is the division ratio of the programmable divider.

It is evident that if we alter n by unity, the output of the VCO will change by F_{ref}. Thus we may use such a synthesizer to generate a number of channel frequencies that are all multiples of the reference frequency. In VHF and UHF synthesizers, channel spacings of 5 to 50 kHz are normally required — synthesizers with channel spacings down to 1 Hz or less may be built, but these would normally use multiloop techniques and are beyond the scope of this article.

output-frequency considerations

The use of integrated circuits is fundamental to the design of this type of synthesizer. The VCO, the phase comparator and the LPF may all be built using discrete components, but using discrete components for a complex circuit such as a programmable divider would entail quite unacceptable penalties of size, cost, reliability, and power consumption. However, the use of integrated circuits at once presents us with a problem: integrated circuit programmable dividers use CMOS, NMOS, or TTL technology and are unable to operate at frequencies higher than 25 MHz (or per-

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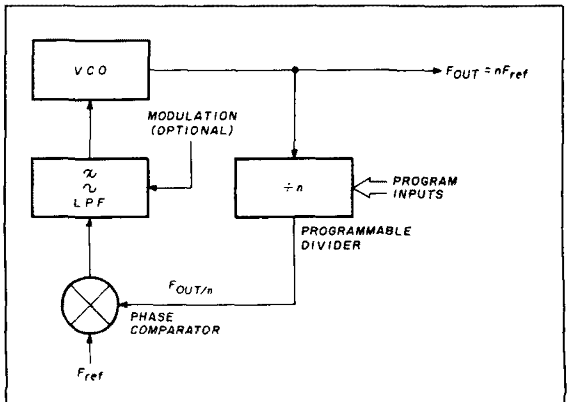

fig. 1. The elements of a basic frequency synthesizer.

haps a little more in the case of Schottky TTL). This is not nearly high enough for use in VHF or UHF synthesizers.

Fig. 2 offers a solution to the problem. A fixed VHF or UHF prescaler, with a division ratio of m, is inserted between the VCO and the programmable divider. This indeed reduces the output frequency to one that the programmable divider can accept, but it introduces a number of new problems. It is, however, widely used since fixed dividers using ECL technology are available with input frequencies of up to 1.8 GHz.

Two of the minor problems of this approach are power consumption (ECL is generally a high-power process) and interfacing. The major, and intractable, one is the effect on F_{ref}. As is obvious, the introduction of fixed prescaling changes the synthesizer law to $F_{out} = mnF_{ref}$. If the same channel spacing is needed, the reference frequency must be reduced by a factor of m (which will generally lie between 10 and 256). This complicates the design of the LPF, makes the time required for the synthesizer to lock greater by a factor of m, and, unless extreme care is taken in the VCO design, markedly worsens the noise and reference sideband levels in the synthesizer output.

mixer synthesizer

In applications where this degradation of performance is unacceptable, the use of a mixer synthesizer is often considered. This technique is shown in **fig. 3**. The VCO output is mixed with a signal of frequency F_M and the difference frequency $(F_{out} - F_M)$ is applied to the programmable divider through an LPF.

Such a system has a number of advantages: F_M may be switched to give i-f and repeater shifts, the power consumption is not usually very high, and it is easily understood. However, it has disadvantages as well: the overall system stability depends on two oscillators with outputs of F_{ref} and F_M, the noise level in both the second oscillator and the mixer is critical for system performance (the noise in the reference oscillator is less important because F_{ref} is usually divided from the reference oscillator through a long divider chain), and the system is more complex. Nevertheless, many synthesized transceivers use this technique even though a better one exists: multimodulus prescaling.

multimodulus prescalers

The simplest form of multimodulus prescaler is the two-modulus prescaler (sometimes called a "swallow counter") illustrated in **fig. 4**. The system works as follows: when the system starts counting, the two programmable counters are reset to zero. The pre-

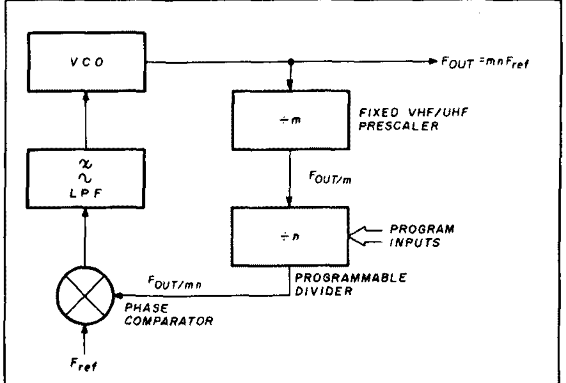

fig. 2. Synthesizer with a fixed prescaler, which is inserted between the VCO and programmable divider. Prescaler reduces the VCO output frequency to one that the divider can accept.

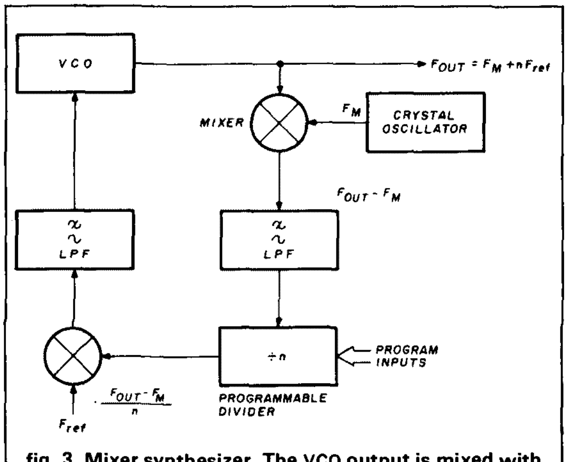

fig. 3. Mixer synthesizer. The VCO output is mixed with a signal of frequency F_M, and the difference frequency $(F_{out} - F_M)$ is applied to the divider through a low-pass filter.

scaler divides the VCO output by $(m + 1)$ and its output pulses increment both programmable counters. When the count reaches a the prescaler modulus is changed to m and the a counter stops at this point; $a(m + 1)$ cycles of the input frequency have been counted. The n counter continues to count the prescaler output until its count reaches n when it passes a pulse to the phase comparator, both counters are reset, the prescaler reverts to $(m + 1)$ ratio and the cycle restarts. In the second half of the cycle the system counts $(n - a)m$ cycles of the input frequency. Thus a full cycle of the counter delivers one output pulse for each $a(m + 1) + m(n - a)$ input cycles. A little algebra reduces this expression to $nm + a$, so the division ratio is $nm + a:1$.

The whole system thus acts as a VHF or UHF programmable counter, although the fully programmable counter need only work at a few MHz, allowing the use of CMOS, NMOS, or TTL. Also, although two programmable counters are required each is less complex than the one in **fig. 2**, so in fact the overall complexity of the system in **fig. 4** is only slightly greater than that in fig. 2 and it has all the advantages of VHF or UHF programmable counting.

There are, of course, some drawbacks. The division ratios of a two-modulus prescaler will normally be between 10/11:1 and 100/101:1, and it is evident that ratios of over 20/21:1 will be required at VHF if the input to the programmable counter is to be at a low enough frequency for the use of CMOS or NMOS.

For an $m/m + 1:1$ prescaler the a counter must be programmable over a range of m. The n counter must always divide by a larger number than the a counter. So for full programmability the total system division ratio must be equal to, or greater than, m^2. This sets a lower frequency limit to the use of such

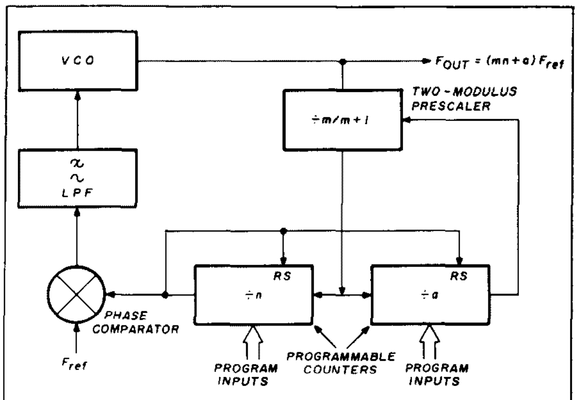

fig. 4. Synthesizer using a two-modulus prescaler. The prescaler divides the VCO output by $(m + 1)$ or m and its output pulses increment both counters.

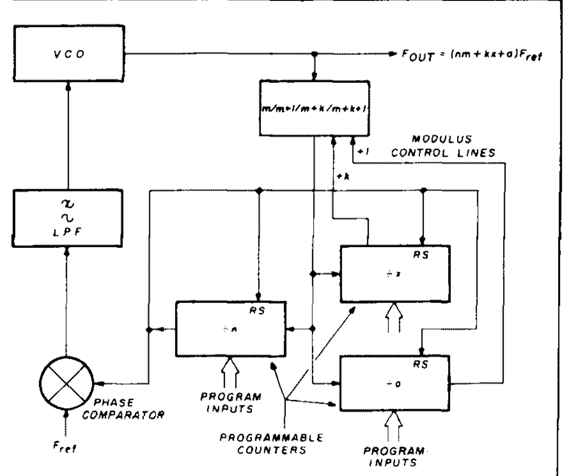

fig. 5. Synthesizer using a four-modulus prescaler for wider tuning ranges.

synthesizers. For example, with 25-kHz channel spacing and a 40/41 prescaler, the minimum division ratio is $40^2 = 1600$ and thus the minimum frequency is 40 MHz. Generally the programmable counter sets limits that are higher than these theoretical minima.

If wider tuning is required, four-modulus prescaling may be used. A typical system is shown in **fig. 5**. Here the prescaler has four moduli: $m/m + 1/ m + k/m + k + 1$, which are set by $+1$ and $+k$ control lines. There are three programmable counters, and the conditions that limit the ratios are:

1. a must count over a range of k.

2. x must count over a range of $\frac{m + k + 1}{k}$.

3. n must count not less than the minimum value of a or k.

For a 55/56/63/64 prescaler this sets a division ratio limit of 512, which allows 25-kHz channel synthesis to go up from 12.8 MHz. Again, in practical systems, the programmable counter will generally set higher minima. The overall division of this system is $mn + kx + a$, where n is the count in the n counter, x is the count in the x counter, and a is the count in the a counter.

Integrated circuit two- and four-modulus VHF and UHF counters have been available for some time, as have general purpose CMOS and TTL programmable counters. Only recently have dedicated LSI circuits become available that can interface directly with two- and four-modulus prescalers. The next part of this article describes some integrated circuits designed by Plessey Semiconductors, Ltd., for use in VHF and

UHF synthesizers using the techniques described above.

From **fig.** 4 it will be seen that a two-modulus prescaler has input and output ports and a control line that is used to alter the division ratio. The input may be balanced or unbalanced (two-line or one-line), but the output and the control will normally work at CMOS/TTL levels. Similarly the four-modulus prescaler shown in **fig.** 5 is almost identical in general structure except that it has two control lines instead of one.

Plessey prescalers

Plessey Semiconductors makes a number of two- and four-modulus prescalers, which are listed in **table 1**. Those of particular interest to the frequency synthesizer designer are the SP8793, SP8906, and SP8901. These will be described in detail.

The SP 8793 is a two-modulus divider with ratios of 40/41. It has CMOS/TTL control and output interfaces and an ac-coupled input with an input impedance of around 500 ohms. It requires 100 mV peak-to-peak input to operate correctly. One of its most useful features is its low power consumption: only 4 mA at 5V (20 mW). It may also be operated from an unregulated supply, 6.8 to 12V, using its own internal regulator. Its upper frequency limit is 200 MHz.

The SP8906 is a four-modulus divider with ratios of 239/240/255/256 and an upper frequency limit of 512 MHz. Again, it has CMOS/TTL interfaces for control and output and an ac-couple input. The SP8906 is not a low-power circuit, requiring some 80 mA at 5V (400 mW). The SP 8901 is an SP8906 with a built-in divide-by-two prescaler capable of working with inputs up to 1 GHz. It also has a consumption of 400 mW. The prescaler, being fixed, causes the channel spacing to be twice the reference frequency, but this is a small penalty to pay for a two-chip synthesizer capable of working at up to 1 GHz.

At frequencies over 1 GHz, separate prescalers or mixing techniques must be used. Use of the Plessey Semiconductors SP8619 with an SP8906 allows the design of synthesizers that work up to 1.8 GHz. The SP8619 is a divide-by-four prescaler that will operate up to 1.8 GHz and can drive an SP8906. Synthesizers using this combination have, of course, a channel spacing of four times reference frequency.

The highest output frequency from an SP8906 or SP8901 is $512/239\ MHz = 2.142\ MHz$. Such a frequency will be within the capabilities of CMOS or TTL logic families. TTL uses a large amount of power and has largely been replaced at frequencies below 4-6 MHz by CMOS, which has a leakage current, when not switching, of a few microamperes. When switching at a frequency of several MHz, however, the current consumption of CMOS rises and studies have shown that a programmable counter working with an input frequency of 2 MHz will use less power if built using NMOS than if built with CMOS. It will also be far smaller.

CMOS uses both P-channel and N-channel MOS devices (hence CMOS or complementary MOS) and therefore requires three or four diffusions during manufacture. Its system of active loads also results in CMOS logic occupying much larger areas of silicon chip than a similar circuit in NMOS or PMOS. These processes have an additional advantage of requiring only one diffusion step during manufacture. This combination of smaller silicon areas and fewer diffusion steps makes NMOS circuits smaller and less expensive than CMOS ones performing the same function. In the limit it means that more complex circuits may be built with NMOS than with CMOS. Plessey has therefore chosen to use NMOS for its NJ8811 and

table 1. Plessey multimodulus prescalers.

device	moduli	frequency (MHz)	control input	output
SP8720	3/4	300	ECL	ECL
SP8692	5/6	200	TTL/ECL	TTL/ECL
SP8740	5/6	300	ECL	ECL
SP8741	6/7	300	ECL	ECL
SP8691	8/9	200	TTL/ECL	TTL/ECL
SP8743	8/9	500	TTL/ECL	ECL
SP8690	10/11	200	TTL/ECL	TTL/ECL
SP8647	10/11	250	ECL	TTL/ECL
SP8643	10/11	350	ECL	ECL
SP8685	10/11	500	TTL/ECL	ECL
SP8680	10/11	600	TTL/ECL	TTL/ECL
SP8785	20/22	1000	ECL	ECL
SP8786	20/22	1300	ECL	ECL
SP8793	40/41	200	TTL	TTL
SP8792	80/81	200	TTL	TTL
SP8906	239/240/255/256	512	TTL	TTL
SP8901	478/480/510/512	1000	TTL	TTL

NJ8812 synthesizer circuits, which are illustrated in **figs. 6** and **7** respectively.

The circuits contain all the logic circuits of a frequency synthesizer with the exception of the VHF/UHF multimodulus counter and the channel programming logic. Otherwise they are complete: programmable dividers, reference divider and phase comparator on a single chip. They also contain a data buffer to enable them to be used with a four-bit data highway for programming. This means that, while they will generally be programmed by means of a ROM and a channel switch, they are compatible with microprocessor-based programming systems as well.

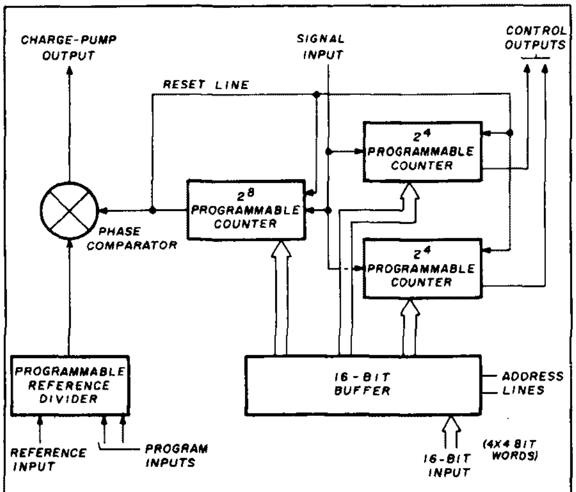

fig. 6. The Plessey NJ8811 synthesizer circuit. All logic is included except for the UHF/VHF multimodulus counter and chennel programming circuits.

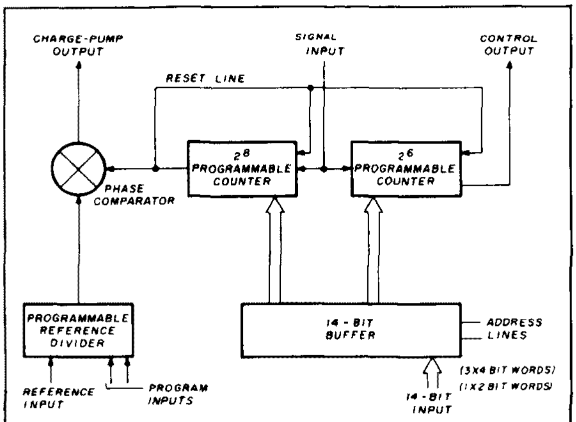

fig. 7. The Plessey NJ8812 synthesizer, which is almost identical to the NJ8811 but is designed to be used with the SP8793 as its prescaler in low-power applications up to 200 MHz.

programming systems as well

The NJ8811 is designed to interface, in the type of synthesizer shown in **fig.** 5, with the SP8906 or the SP8901. Using the first pair (SP8906 + NJ8811), a synthesizer may be designed to operate in the range of 40-512 MHz. The programmable reference divider, which uses four state input lines to allow the programming of sixteen reference divider ratios with only two program control lines, allows the choice of sixteen channel spacings from a single, standard, 4.8-MHz reference input. (In the interest of stability the reference oscillator is not included on the chip.) These channel spacings include 30, 25, 20, 15, 12.5, 10, 7.5, 6.25, 5, 3.75, 3.125, and 2.5 kHz. When the NJ8811 is used with the SP8901 both channel spacings and frequency ranges are doubled.

The NJ8812 is almost identical to the NJ8811 but is designed to be used with the SP8793 as its prescaler in low-power synthesizers at frequencies up to 200 MHz. The NJ8811 and NJ8812 draw only 8 mA at 5V. The combination of NJ8812 and SP8793 has an average power of some 50-60 mW, which makes it ideal for use in hand-portable radios where battery life is important.

computer program

A BASIC program is available that may be used to design VHF and UHF synthesizers using the integrated circuits described in the article.* The program is in two parts: the first requests the frequency limits, channel spacing, injection mode and other details of the required synthesizer and determines which circuits should be used and how they should be connected. It also considers the choice of reference frequency and reference division ratio with a view to minimizing reference harmonics in the working band. The second half of the program requests details of the individual channels required and provides ROM programming information for them.

The program was written for a Commodore PET 2001-8 desktop computer, although it will no doubt run in any BASIC machine with minor modifications. The extremely compact form used for the program, combined with the lack of REM statements, is due to memory limitations of the machine involved. The program runs with fewer than 300 bytes of the memory unused. If a large machine were available, no doubt the program could be edited to be more easily understood; but in its present form it works well and is a very useful aid in the design of frequency synthesizers in the VHF and UHF range.

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*Copies of the program may be obtained from *ham radio* upon receipt of a stamped, self-addressed business size envelope.

tandem pi networks

Analysis of 3000:50 ohm matching networks with emphasis on second-harmonic attenuation

In an earlier article[1] the input impedance characteristics versus frequency for commonly used pi and pi-L networks were shown and discussed. It was shown that the pi-L is considerably sharper than one would expect from the design Q (normally taken as 10), so that a design Q of 8 or even 7 results in an acceptable design.

Further study has now been made of the *current* response of several representative pi, pi-L, and tandem pi networks, with particular reference to the second-harmonic attenuation. (Current response is the magnitude and phase angle of the ratio of output current into a 50-ohm resistive load to an assumed input current to the network.) As in the earlier article[1] this has been done using a program written for the HP-34C programmable calculator. The following discussion centers mainly on the 3000:50-ohm matching networks of various Qs and configurations.

second-harmonic considerations

For a design Q of 10, the conventional shunt-capacitor pi network (-300 ohms input, 321.6 ohms series inductance, and -60.5 ohms output) has a second harmonic response of -33.4 dB. In other words, with 1 kW at the fundamental, there can still be about 0.47 watt radiated at the second harmonic. This assumes, of course, a) that there is appreciable harmonic content in the original wave, which would only be the case with class-C amplifiers driven hard for high efficiency and a low conduction angle, and b) that the *load* at the second harmonic remains a pure resistance of 50 ohms. With modern linears, the situation is not that bleak, and unless a multiband antenna is used, it is rare that the second-harmonic impedance would remain at 50 ohms resistive.

With the pi-L, again with a design of Q *of 10 and* shunt capacitors, the second-harmonic response improves to -47.3 dB. Dropping the Q to 8 reduces the response to -45.9 dB. This is more than adequate even for a class-C amplifier, since 40 dB represents an attenuation of 10,000.

network input elements

One is tempted, then, to use a pi-L network with shunt *inductance* at the input, and with series capacitance for the first series element. The reason is that the shunt-feed rf chokes used in high-power amplifiers are often trouble producers. They may burn out with a flashover, the pancake types crawl together due to the magnetic forces involved, and there are numerous unwanted responses in most rf chokes that can give rise to parasitics. Using series feed (inductance for the input reactance of the matching network), one not only gets away from the rf choke by feeding plate voltage directly to the coil, but the series dc blocking capacitor is eliminated as well, because the series capacitor in the network can stand off the dc. (The usual bypass at the power-supply end of the input coil is, of course, still required — and now more than ever).

For a design Q of 10, the 3000:50 ohms inductance-input pi-L would have values $X_1 = 300$, $X_2 = -194$, $X_3 = -63.8$, and $X_4 = 129.9$ *ohms*. But the

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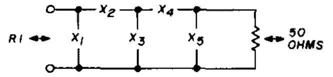
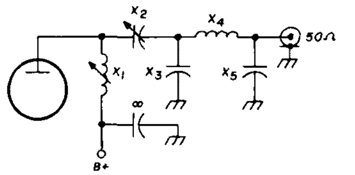
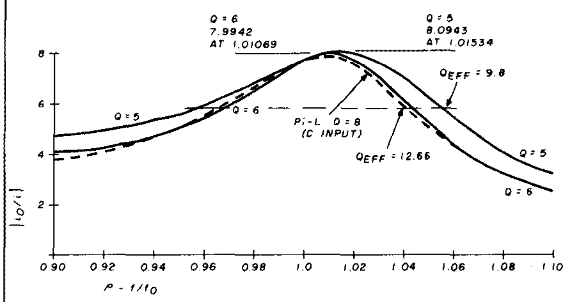
table 1. Tandem pi designs with inductance input (values in ohms).

Q	R_1	X_1	X_2	X_3	X_4	X_5
	3000	600.0	−399.8	−59.3	97.3	−32.6
	2750	550.0	−361.4	−56.3	93.9	−31.6
5	2500	500.0	−323.4	−53.3	90.2	−30.6
	2250	450.0	−285.9	−50.1	86.4	−29.5
	2000	400.0	−248.9	−46.8	82.3	−28.3
	3000	500.0	−328.9	−48.8	83.1	−25.7
	2750	458.3	−297.5	−46.4	80.1	−25.7
6	2500	416.7	−266.4	−43.9	77.0	−24.3
	2250	375.0	−235.6	−41.3	73.7	−23.5
	2000	333.3	−205.3	−38.6	70.1	−22.7







HARMONIC RESPONSE

	Q = 5	Q = 6	C INPUT Pi-L Q = 8
ρ = 2	−40.2dB	−42.5dB	−45.90
ρ = 3	−52.9dB	−55.3dB	−61.97
ρ - 4	−61.1dB	−63.5dB	−72.60

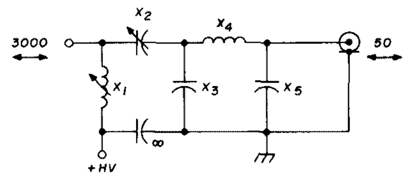


fig. 1. Inductance-input tandem-pi network i_o/i response, 3000:50 ohms impedance transformation.

second-harmonic attenuation of this network is only 32.9 dB — slightly less than the conventional pi. Compared with the shunt-capacitance pi-L, it is really disappointing: 32.9 dB versus 47.3 dB.

the tandem pi configuration

So this leads to the consideration of a *tandem-pi* network. Another program was developed for the HP-34C (for a copy, send an SASE to *ham radio*, Greenville, NH 03048), to yield the reactance values for the tandem pi, based on the assumptions of a) equals *Q*s and b) equal transformation ratios for each pi section. **Table 1** gives the values for two inductance-input tandem-pi designs for design *Q*s of 5 and 6 and five different, but typical input resistances all matching to 50 ohms. Design *Q*s of 5 and 6 were found acceptable in terms of effective *Q* (measured by the frequency difference between frequencies for 70.7 percent of the maximum current ratio) and also in terms of second-harmonic attenuation.

Taking the 3000:50 ohm tandem pi as typical, the current response curves (magnitude and phase) are shown in **fig. 1**. The second-harmonic attenuation is −40.2 dB and −42.5 dB, respectively, for the two *Q* values, and the effective *Q* is 9.8 and 12.66. The curve for a capacitor-input pi-L, $Q=8$, is shown for comparison.

Note from **table 1** that the *variation* in the fairly low shunt reactances, and even in the second inductance, is not great over the range of input resistances. Thus only the input inductance, X_1, and the first series capacitor, X_2, would have to be made variable over any appreciable range for a given band; the others could either be fixed at some average value or be trimmed by a relatively small variable across them.

Thus if one has a roller coil as large as 28 microhenries (80 meters) for X_1, and a 15-220 pF high-voltage variable for X_2, the remainder of the network can probably be fixed for any given band. The voltage across X_3 would be only about 650 volts rms for a 1-kW linear, and across X_5 it would be about 250 volts rms.

So by the addition of essentially one more component (X_5) over the pi-L, an acceptable harmonic attenuation and effective *Q* can be obtained using shunt inductance at the input of the tandem-pi matching network. This, then, saves one high-voltage blocking capacitor and the usual shunt-feed rf choke. The penalty, of course, is a variable inductance for the input coil, and a coil that is at high-voltage dc potential. Whether this trade-off is acceptable depends on the user.

reference

1. R.W. Johnson, W6MUR, "Response of pi, pi-L, and Tandem Quarter-Wave-Line Matching Networks," *ham radio*, February, 1982, page 12.

ham radio

owners survey: 2-meter handhelds

The most popular 2-meter handies are evaluated by the readers of *ham radio* magazine

Editor's Note: Several of these handheld rigs have been superseded by later models. We feel that the information presented here is still very useful, however, both to hams thinking of buying a used rig as well as to those who want information on the basic radios, which remain essentially unchanged by most minor modifications.

Two-meter handheld radios have become very popular. Aside from their obvious value for emergency and public-service work, there is great appeal to the idea of being able to communicate over wide distances with a portable little radio small enough to clip onto your belt. Wherever you go, whether it's into the woods on a camping trip or out on the lake for a day of fishing or just down to the store for a quart of milk, instant communications is always at hand.

Portable radios, of course, have been around for many years. The difference is that now, with the combination of IC microminiaturization, frequency synthesizers, and a network of repeater stations, handheld portables can offer reliable communications over wide areas. Working into a good repeater, a handheld 2-meter transceiver can put you in touch with Amateurs virtually anywhere within an area of thousands of square miles. Today's handhelds are lightweight, small, and — best of all — inexpensive when compared with most Amateur transceivers.

The purpose of this reader survey was to find out what the Amateurs who own them think of each of the seven most popular synthesized 2-meter handhelds. Perhaps the opinions of other Amateurs will help you decide which 2-meter handheld is the one for you. The seven radios reported on were the Santec HT-1200, the Tempo S-1 and S-5, the Icom IC-2AT and 2A, the Yaesu FT-207, and the Kenwood TR-2400. Here are the results.

By Martin Hanft, KA1ZM, Managing Editor, *ham radio* magazine

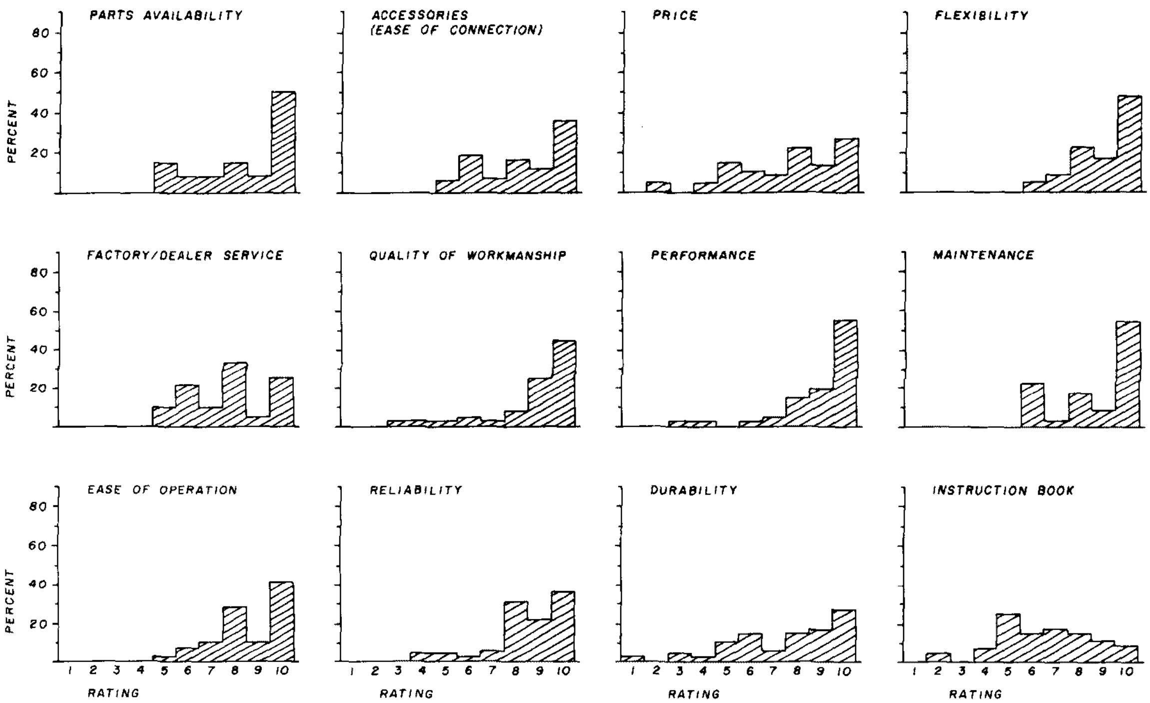


fig. 1. Owners' opinions on the Santec HT-1200.

Santec HT-1200

The HT-1200 is a fully synthesized, 3.5-watt rig with scan and search features plus ten memories. It has a sixteen-key keyboard and LED frequency readout. Fifty-nine usable reports were received on the Santec HT-1200.

Of the owners of the HT-1200 who responded to this questionnaire, fifteen percent were Technicians, twenty-nine percent were Generals, forty-one percent were Advanced-class, and fifteen percent Extras. Ninety-five percent had purchased the radio new. Sixty-five percent bought their radio from a dealer, while only twenty percent bought from a mail-order company. About eleven percent bought their rigs from an 800-number. Ninety-three percent of those who responded, when asked if they would buy from the same source again, said that they would.

When asked whether this was their primary or backup 2-meter fm rig, fifty-two percent indicated that it is their backup rig.

When asked, What is the best feature of this rig?, fifty-one percent mentioned the frequency-scanning ability of the radio. A close runner-up in the percentages, with forty-three percent, was the pre-programmed memory. Thirty-six percent mentioned the high/low power feature of the radio, and fourteen percent made mention of the sixteen-key keyboard. Other aspects of the radio that received praise were its versatility, small size, and out-of-band capability. Note that many respondents listed more than one "best feature."

When asked to list the worst feature of the HT-1200, twenty-seven percent replied that the battery life is too short, and that the batteries must be changed or recharged too often. This was to prove to be a complaint common among the users of all the handhelds reviewed. Of course, some rigs will draw more current than others, and with some handhelds changing battery packs is more of a chore than it is with some others. But owners of all the most popular handhelds seem to feel that the batteries drain too fast. Another problem common to all the handhelds is that the nickel-cadmium batteries don't give much warning before they become discharged and fail. This is a problem inherent to Ni-Cd batteries.

Twenty percent of the HT-1200 owners faulted the radio for having an LED frequency readout that is virtually impossible to read in bright sunlight. Several also mentioned the added battery drain associated with the use of LEDs (as opposed to liquid-crystal displays).

The third most common complaint mentioned by owners of the HT-1200 (ten percent) was the lack of a belt clip. Other "worst" features mentioned by smaller percentages were inadequate instruction book, lack of an external dc input, and difficulties getting used to the operation of the radio.

To the question, Have you had any problems?, fifty-three percent answered no. Of those who did report having had problems, the most common com-

Santec HT-1200

General

Power consumption: RX 90 mA (45 mA squelched);
TX 900 mA (high), 500 mA (low)
Dimensions: 68 × 170 × 47 mm (2.7 × 6.7 × 1.9 inches)
Weight: 700 g (1.5 lbs.)
Memory channels: ten
Odd splits: yes
Readout: LED
Scanning: yes

Transmitter

Power output: 3.5 watts/1 watt

Receiver

Sensitivity: 0.35 μV for 12 dB SINAD
Selectivity: ±7.5 kHz at 6 dB down; ±15 kHz at 60 dB down
Audio output: not specified

Features

Four modes of automatic scan and search, up/down variable scan steps, keyboard entry of frequencies, 16-button Touchtone pad, flexible antenna, Ni-Cd pack, charger, earphone, strap

Options

Case, speaker/mike, mobile charger, desk charger, subtone unit, remote speaker, battery packs

plaint (mentioned by fourteen percent) was trouble with the audio quality. A variety of other problems showed up in the survey, each mentioned by fewer than four percent of the respondents. These included a few instances of battery-pack problems, some trouble with dial lights, birdies, blown final, and hum.

Twenty-six percent of the owners of the HT-1200 reported that some servicing had been done on their radios, and, among those who had had service work performed, seventy-three percent said that the service was satisfactory. Eighty-eight percent said that they had been able to obtain all the accessories and parts they needed, and eighty-five percent said that they had been satisfied with those accessories.

The accessory most popular with owners of the HT-1200 was the leather case (73 percent). Fifty-seven percent reported buying an additional (whip) antenna, and fifty-two percent purchased a speaker/mike. Forty-three percent bought desk or mobile chargers as accessories, and twenty percent bought additional battery packs. Another popular accessory was the belt clip.

Question 17 asked respondents to rate the radio, scored from one to ten, on the basis of Ease of Operation, Reliability, Durability, Instruction Book, Factory/Dealer Service, Quality of Workmanship, Performance, Maintenance, Parts Availability, Accessories, Price, and Flexibility. The results are tabulated in **fig. 1**.

To the final, and most important, question, Would you buy this rig again?, eighty-nine percent replied yes.

Tempo S-1/S-5

The Tempo S-5 differs from the S-1 in that it produces five watts power (or 1 watt when switched to low power). Both models come with twelve-key Touchtone pad and telescoping quarter-wave whip. One hundred and fifteen usable reports were received on the Tempo S-1/S-5. Twenty percent of those responding were Technicians, thirty-two percent were Generals, forty percent were Advanced-class, and eight percent were Extras.

Among the owners of the S-1/S-5, seventy-eight percent had bought the radio new, with sixty-four percent buying their rig from a dealer, thirteen percent from a mail-order house, fifteen percent from another individual, and about five percent buying from 800-numbers. Ninety percent of those responding said that they would buy from the same source again. Fifty-two percent said that this radio is not their primary 2-meter fm rig, but rather is a backup radio.

When asked to list the best feature of the Tempo S-1/S-5, twenty-eight percent responded by mentioning the small size of the radio. Twenty-three percent mentioned ease of operation, and sixteen percent mentioned the radio's durability. Also ranking

Tempo S-1/S-5

General

Power consumption: RX 120 mA (17 mA squelched);
TX 400 mA (S-5)
Dimensions: 62 × 165 × 40 mm (2.5 × 6.5 × 1.6 inches)
Weight: 482 g (1.1 lbs.)
Memory channels: none
Odd splits: no
Readout: thumbwheel
Scanning: no

Transmitter

Power output: 2 watts (S-1); 1 or 5 watts (S-5)

Receiver

Sensitivity: better than 0.5 microvolts nominal for 20 dB
Selectivity: ± 6 kHz bandwidth at least 6 dB down;
± 12 kHz bandwidth at least 60 dB down
Audio output: at least 750 milliwatts on internal speaker with less than 10% distortion

Features

Telescoping whip antenna, plug-in charger, earphone, Ni-Cd pack

Options

Leather holster, 16-button Touchtone® pad, helical antennas, amplifiers, cigarette lighter charger, tone encoders

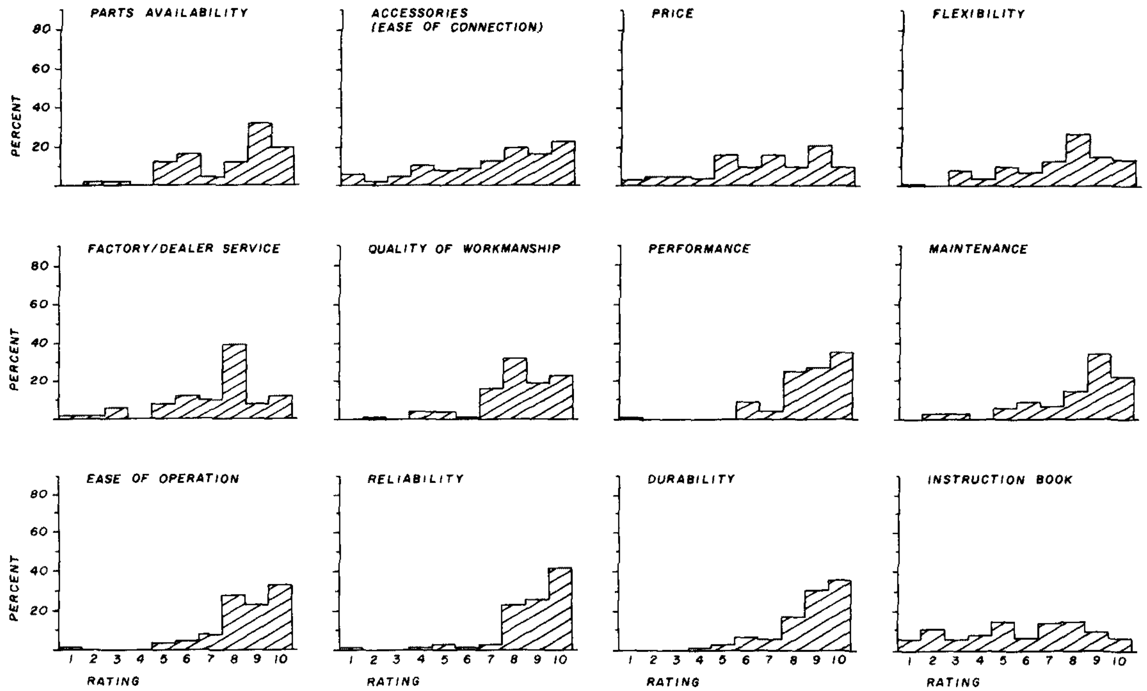


fig. 2. Owners' opinions on the Tempo S-1/S-5.

high were the synthesizer (fifteen percent), the light weight of the radio (fourteen percent), and the radio's *dependability (twelve percent).*

When asked to list the worst feature of the radio, thirty percent of those responding mentioned the external-antenna jack connection, which does not use a BNC-type connector and thus can be inconvenient when connecting an external antenna. The second most frequently mentioned "worst" feature of the radio was difficulty in changing batteries and the lack of a separate battery pack. Other "worst" features *included, once again, the fact that the batteries* don't last long enough (twenty percent), dirt collecting in the frequency-control wheels (nine percent), and the plastic case not being of heavy enough construction (seven percent).

To the question, Have you had any problems?, forty-eight percent replied no. Among those who did report problems the most common sources of trouble were blown finals (eight percent), wiring intermittents (eight percent), and failed chips (four percent).

Twenty-nine percent of those responding said that they had had some service work performed on the radio, and among those who had, ninety-three said that the work was satisfactory.

As to accessories for the S-1/S-5, the most common accessory purchased was a rubber-duck-type antenna, which was bought as an accessory by forty-five percent of those who bought the S-1/S-5. The second most common accessory was the leather case (twenty-five percent), followed by the speaker/mike (fifteen percent), a charger (fourteen percent), a 12-volt adapter (fourteen percent), and a belt clip (thirteen percent). To the question, Have you been able to obtain all the accessories and parts you need?, ninety percent answered yes. Eighty-five percent said that they were satisfied with the accessories they had bought.

For a numerical scoring of how the S-1/S-5 was rated by our readers, see fig. 2.

To the question, Would you buy this same rig again?, seventy-four percent of our respondents answered yes.

ICOM IC-2A/2AT

The ICOM IC-2A and 2AT (Touchtone® version) has a high (1.5 watts)/low (0.15 watt) power feature and comes with a "rubber duck" antenna. Two hundred and thirty-four usable responses were received from our readers, of whom twenty-two percent were Technicians, eighteen percent Generals, thirty-eight percent Advanced-class, and twenty-two percent Extras.

Ninety-eight percent of the owners of the 2A/2AT had bought the radio new. Sixty-two percent purchased the radio from a dealer, and twenty percent bought the radio from mail order. Only twelve percent purchased the rig from an 800-number. Ninety-five percent said that they would buy from the same source again.

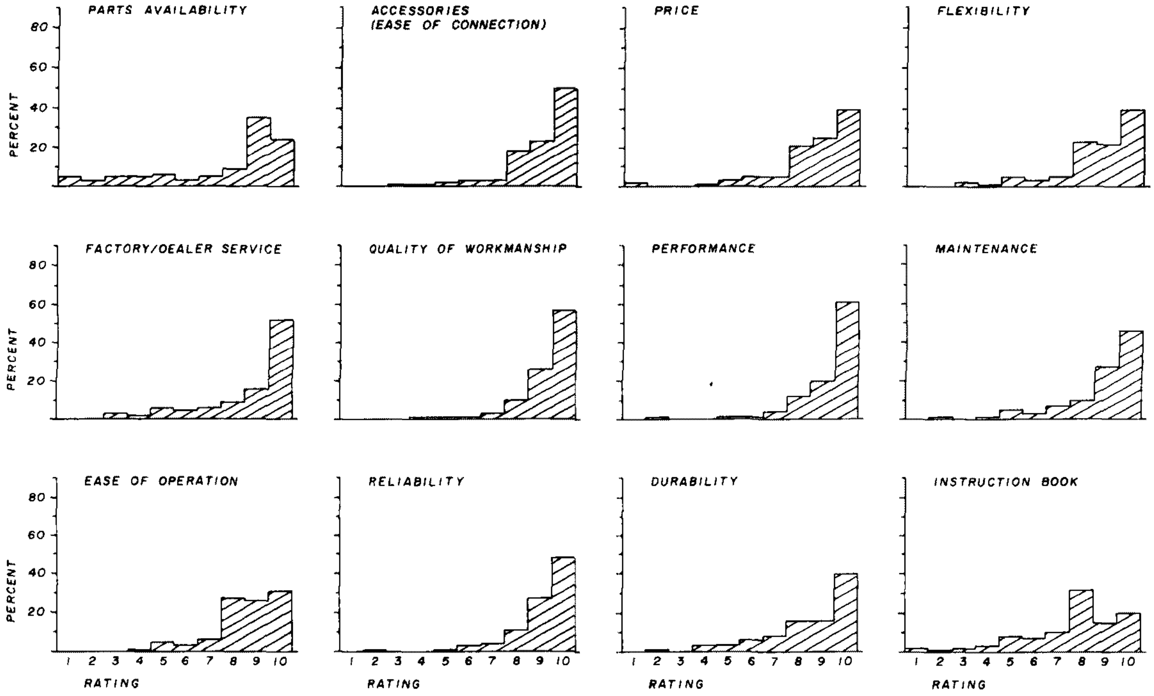


fig. 3. Owners' opinions on the ICOM 2A/2AT.

When asked whether the rig is their primary or backup 2-meter fm radio, the responses were roughly evenly split, with fifty-two percent using the radio as a backup 2-meter rig.

ICOM 2A/2AT

General

Power consumption: RX 130 mA (20 mA squelched);
TX 550 mA (high), 220 mA (low)
Dimensions: 65 × 165.5 × 35 mm (2.6 × 6.5 × 1.4 inches)
Weight: 490 g (1.1 lbs.)
Memory channels: none
Odd splits: no
Readout: thumbwheel
Scanning: no

Transmitter

Power output: 1.5 watts/0.15 watt

Receiver

Sensitivity: less than 0.5 μV for 20 dB noise quieting
more than 26 dB S + N + D/N + D at 1 microvolt
Selectivity: ±7.5 kHz at 6 dB down; ±15 kHz at 60 dB down
Audio output: more than 300 mW

Features

Flexible antenna, Ni-Cd pack, wall charger, earphone, wrist strap, belt clip

Options

Cigarette lighter cord, base stand charger, speaker/mike, case, dc regulator, battery packs and cases

In response to the question, What is the rig's best feature?, the most common response was small size, which was mentioned by fifty-four percent of those responding. Thirty-one percent mentioned the quick-change battery packs, which make it possible to insert fresh batteries without taking the radio apart. Fourteen percent mentioned ease of operation, and eleven percent mentioned price as a best feature. The quality of the receiver was mentioned by ten percent, and audio quality and reliability were each mentioned by about eight percent.

When asked, What is the rig's worst feature?, our respondents mentioned switch positions on the back of the radio most often (twenty percent), and the fact that the switches are too close together. Seventeen percent said that the batteries drain too fast, and eleven percent mentioned that the audio output is too low to be heard well in noisy environments. About eight percent mentioned difficulty in getting accessories, and an equal number said that there is no room for PL in the 2AT. (Recently, Communications Specialists, 426 West Taft Avenue, Orange, CA 92667 has come out with a programmable, sub-audible tone encoder that fits inside the 2AT and sells for about $30.00.) A small number of respondents mentioned intermod and difficulty in reading the numbers on the frequency wheels.

To the question, Have you had any problems?,

sixty-six percent said no. About six percent mentioned problems with intermittents, and another five percent mentioned wiring problems or shorts. There were a few instances of blown finals, Touchtone pad difficulties, charging problems, and bad capacitors, but the percentages were each well below five percent.

Sixteen percent of those responding said that some service work had been done on their radio, with sixty-six percent of that service work done by the manufacturer, twenty-six percent by the dealer, and the remainder by other sources. Eighty-nine percent of those who had service work performed were satisfied with the work done.

The accessory most popular among owners of the Icom 2A/2AT was the speaker/mike, which was purchased by fifty-two percent of those responding. Nearly as many, fifty-one percent, purchased extra battery packs. Thirty-seven percent bought a charger, and twenty-eight percent a dc power adapter and dc regulator. Eight percent purchased a case, and seven percent a quarter-wave antenna.

See **fig. 3** for a numerical scoring on the Icom 2A/2AT.

Finally, when asked, Would you buy this same rig again?, an impressive ninety-six percent replied yes.

Yaesu FT-207

The Yaesu FT-207 is a 2.5-watt, fully synthesized radio that features LED digital display, memory, and scanning capability. One hundred and twenty-six reports were received on the FT-207. Of those responding, twelve percent were Technicians, thirty-one percent Generals, forty percent Advanced-class, and seventeen percent Extras.

Ninety-four percent of those who reported on the FT-207 had bought their radios new. Fifty percent bought them from a dealer, twelve percent by mail order, twenty-five percent from an 800-number, and the remainder from other sources. When asked if they would buy from the same source again, eighty-nine percent said that they would.

To the question, Is this your primary or backup 2-meter fm rig?, the split was an even 50-50.

When asked to list the best feature of the Yaesu FT-207, thirty-four percent mentioned the frequency-selection ability and the scanning feature of the radio. Twelve percent voted for ease of operation, and another twelve percent mentioned the switchable power feature of the radio. About ten percent mentioned the four memories, and seven percent the small size of the radio.

When asked to list the worst feature of the radio, forty-six percent replied that the worst feature is difficulty reading the LED display when the radio is in direct sunlight. Forty-four percent said that the batteries do not last long enough. Seven percent of those reporting said that the keyboard is too small, and

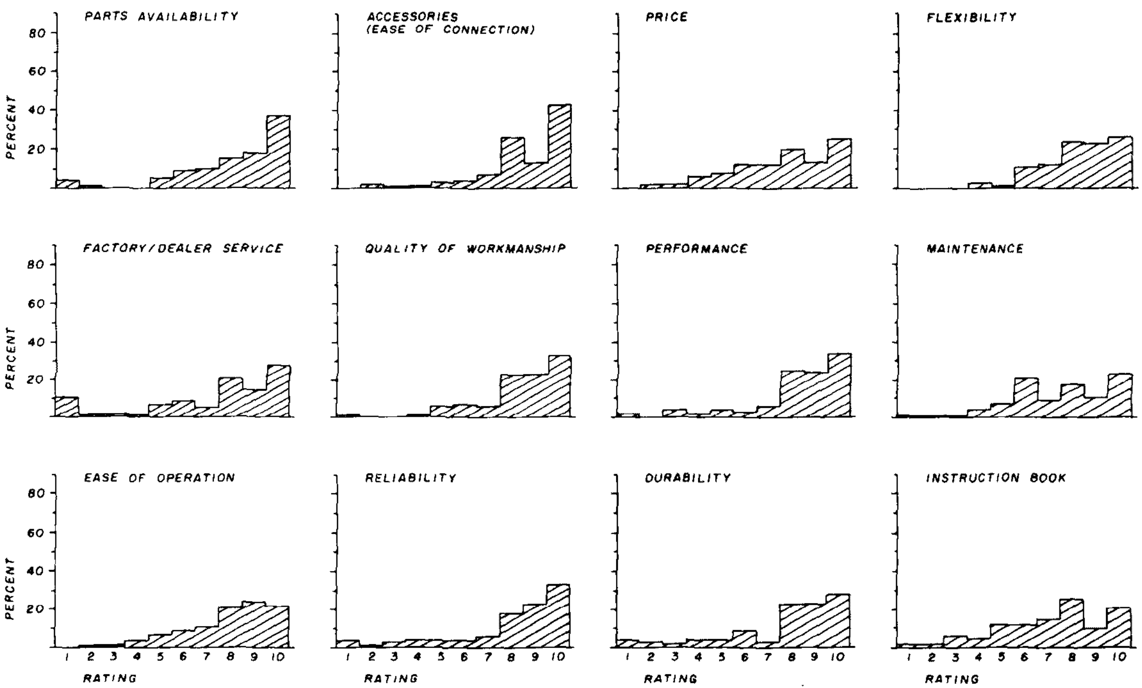


fig. 4. Owners' opinions on the Yaesu FT-207.

Yaesu FT-207

General

Power consumption: RX 150 mA (35 mA squelched, display off); TX 800 mA (high), 250 mA (low)
Dimensions: 68 × 181 × 54 mm (2.7 × 7.1 × 2.1 inches)
Weight: 680 g (1.5 lbs.)
Memory channels: four
Odd splits: yes
Readout: LED
Scanning: yes

Transmitter

Power output: 2.5 watts/200 mW

Receiver

Sensitivity: 0.31 μV for 20 dB quieting
Selectivity: ±7.5 kHz at 60 dB down
Audio output: 200 mW at 10% THD

Features

Keyboard entry of frequencies, up/down manual scan or auto scan for busy/clear channels, 10-kHz scanning steps, flexible antenna, Ni-Cd pack, charger

Options

Quick charger, speaker/mike, tone squelch, case, battery packs, charger, dc adapter, mobile bracket

smaller percentages (less than five percent each) complained of the inability to resume scanning and problems with battery contacts.

To the question, Have you had any problems?, fifty-two percent responded no. The most commonly mentioned problems were hum on the transmitted signal and difficulties with the memory function, mentioned by seven and six percent respectively. Five percent reported microprocessor problems, and although there were a variety of other difficulties mentioned, no other single difficulty was reported by more than four percent.

Thirty-three percent of the FT-207 owners reported that some servicing had been done on their radio, and seventy-one percent of those who had had service work done said that the work was satisfactory.

Ninety-six percent had been able to obtain all the accessories that they needed, and ninety percent said that they were satisfied with those accessories. The most popular accessory was the charger and mobile converter, purchased by thirty-nine percent of those responding, followed closely by the speaker/mike with thirty-seven percent. Thirty-three percent bought an extra battery pack, and thirty-two percent a quarter-wave or five-eighths antenna. Other popular accessories included a case (fifteen percent) and amplifier (seven percent).

Fig. 4 shows the result of the tabulation of the answers to question 17, which asked owners to score the radio in twelve categories of performance.

To the question, Would you buy this rig again?, seventy-five percent answered yes.

Kenwood TR-2400

The Kenwood 2400 is a scanning radio that has ten-channel memory, LCD digital readout, and rf output of 1.5 watts. One hundred and thirty-four usable reports were received on the TR-2400. Twenty-one percent of the owners responding were Technicians, fourteen percent were Generals, forty-seven percent were Advanced-class, and eighteen percent were Extras.

Ninety-two percent of the TR-2400 owners reported that they had bought their radios new. Fifty-five percent of those responding had bought the radio from a dealer, eighteen percent by mail order, seventeen percent from an 800-number, and six percent from another ham. Ninety-three percent said that they would buy from the same source again.

The TR-2400 was the primary 2-meter fm rig for forty-six percent of those responding, a backup rig for fifty-four percent.

To the question, What is the rig's best feature?, thirty-five percent of those responding said that it is the ease of frequency selection and the ten memories. Twenty-two percent mentioned the scanning ability of the radio, and the synthesized circuitry was mentioned by twenty percent. The ±600 kHz reverse switch and the LCD readout each received mention

Kenwood TR-2400

General

Power consumption: RX 28 mA; TX 500 mA (Note: Backup memory, power OFF 2 mA)
Dimensions: 71 × 192 × 47 mm (2-13/16 × 7-9/16 × 1-7/8 inches)
Weight: 740 g (1.62 lbs.)
Memory channels: ten
Odd splits: yes
Readout: LCD with lamp
Scanning: yes

Transmitter

Power output: 1.5 watts

Receiver

Sensitivity: Less than 0.2 μV for 12 dB SINAD
Selectivity: ±12 kHz at 6 dB down; ±24 kHz at 60 dB down
Audio output: more than 200 mW

Features

LCD arrow indicators, up/down manual scan, automatic memory scan, RX/TX reverse switch, two lock switches, flexible antenna, Ni-Cd battery pack, ac charger, hand strap, earphone

Options

Quick-charge base stand, quick charger, case, battery pack, belt hood, speaker mike

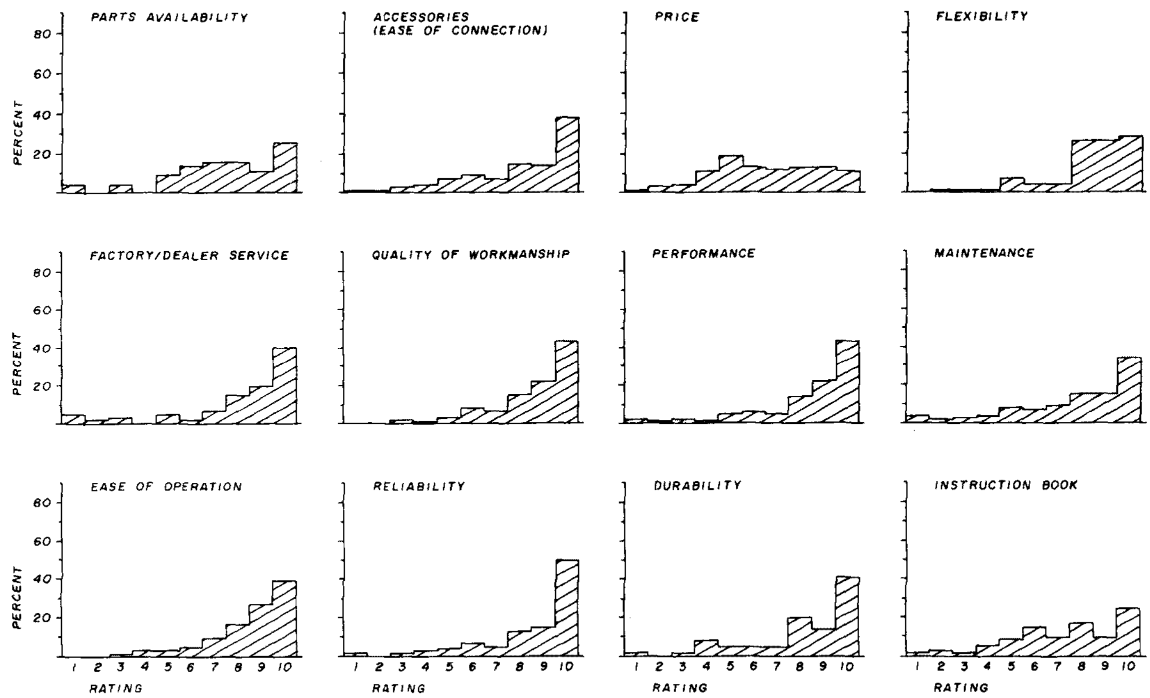


fig. 5. Owners' opinions on the Kenwood TR-2400.

by about fifteen percent of the owners of the TR-2400. The radio's general reliability, ability to make odd frequency splits, and the fact that it does not require many accessories were all mentioned by roughly ten percent of those responding.

In response to the question, What is the rig's worst feature?, seventeen percent said that the worst feature is the short battery life. Fifteen percent said that the scanning rate is too slow, and fourteen percent mentioned difficulty in changing batteries. About ten percent of those responding said that the worst feature is the lack of a high/low power switch, and about eight percent said that the radio is too big. Eight percent also faulted the radio for its lack of an S-meter. Six percent said that the radio is too heavy.

When asked what problems they had had with the TR-2400, forty-three percent of those responding said none. Ten percent mentioned bad solder connections, and eight percent mentioned noise in the audio. There were a few instances of charging difficulties, intermittents and loose screws, but none of these was mentioned by more than five percent of those replying.

Forty-one percent reported that some service work had been done on their radios, with eighty-four percent of those who had work done reporting that the service had been satisfactory. Ninety-one percent of the owners of the TR-2400 said that they had been able to get all of the accessories they needed, and ninety percent said that they were satisfied with the accessories they purchased.

The most popular accessory with owners of the TR-2400 was the speaker/mike, purchased by thirty-eight percent of those responding. Thirty-five percent reported buying the quick charger. Twenty-eight percent bought the leather case, and twenty percent bought additional battery packs. Other popular accessories included the base stand (eighteen percent) and an external whip antenna (sixteen percent).

Responses to question 17, which rates the radio in each of twelve categories of performance, are shown in **fig. 5.**

To the question, Would you buy this rig again?, eighty-three percent said yes.

It's hoped that this review of some of the most popular 2-meter synthesized handhelds will help you to decide which radio is the right one for you. All are different, and all have their advantages and disadvantages. All of these radios, however, are marvels of advanced technology and miniaturization. They're handy for emergency communications use, field use, or as a backup for the base station. And most of all, they're a lot of fun to use.

In an upcoming issue, *ham radio* will be asking its readers to send in their opinions of, and experiences with, linear amps. Be on the watch for it.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

Just before a 160-meter contest the other day, I was listening to determine how good (or bad) DX conditions were. It was early evening and there wasn't much activity around the DX portion of the band. While tuning around 1800 kHz, I suddenly ran across a signal just outside the band edge. I thought it was a ham skirting too close to the edge, but the signal sounded odd and resembled a one-sided conversation. Upon close examination, it turned out to be a frequency-modulated carrier with one side of a telephone circuit on it!

More tuning around revealed several similar fm signals that popped on and off in the 1700 to 1800 kHz range. One such signal, quite loud, sounded like a teen-ager having a long conversation about girl friends, homework, and borrowing "the old man's car" for a hot date. During one long-winded conversation (of which I could only hear one side) the address of the speaker was given. It turned out to be a home about three miles away!

What were these mysterious telephone calls? I logged eight or nine of them between 1700 kHz and 1810 kHz. Some voices were weak; others were very strong. Obviously, they were all within a few miles of my antenna. Inquiries among my ham friends revealed nothing. No one other than myself had noticed the mysterious transmissions and no one knew where they came from or the reason for them. What was going on?

In the next few days I talked at random to other 160-meter operators. They had not noticed the signals, but they quickly found some when I told them to look just outside the low edge of the band. Once or twice, a signal was found just on the band edge, or slightly inside the band.

The mystery was quickly solved when I found an electronics magazine which gave a complete run-down on a relatively new device: the cordless telephone (**fig. 1**). This is a device which connects to the phone line and provides a remote two-way terminal for the user. Various models provide pushbutton dialing, a memory bank for several dozen phone numbers, number redialing, mute switch, and other attractive bells and whistles.

The particular cordless phone that I'd heard is a design that has a base station that transmits an fm signal in the frequency range of 1.6 MHz to 1.8 MHz and receives in the range of 29 MHz and/or 49.8 MHz to 49.9 MHz. The most commonly used frequencies are 1.665 MHz and 29.255 MHz. Alternatively, a channel in the 49-MHz range is commonly used in the United States instead of the 29-MHz channel.

Experience has shown that these units are audible over a several-mile range on the so-called 160-meter channel. The advertised operating range is said to be 100 to 200 meters and this is probably so, because of the limitations of the 49-MHz link and the small receiving antenna used for the low-frequency link. One manufacturer[1] states, "Our model has an effective operating range of less than 100 meters, and is considered an indoor model. The market will not increase until we can push up the operating range to one to 10 kilometers." Another manufacturer is developing a model with an operating range of 1,000 meters for production in 1982.

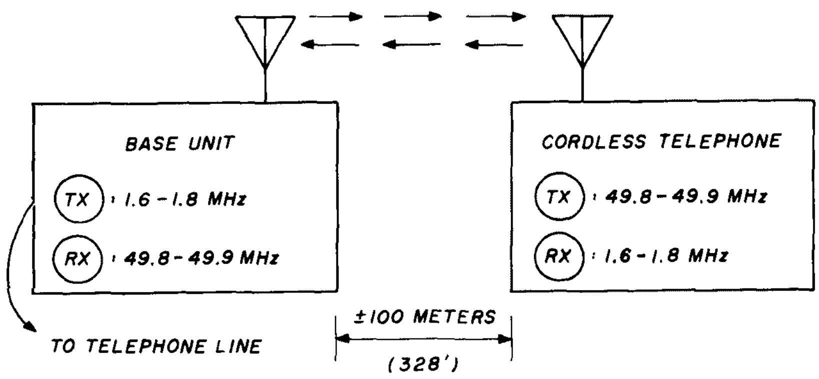


fig. 1. Typical "cordless telephone," model CP-911, marketed by Wenping International under the "Silware" brand name. A U.S. buyer is now applying for FCC approval of this system. Wenping hopes to introduce an improved model with a guaranteed range of 3280 feet (1000 meters).

the future of the cordless telephone

What will the future bring? Some models of the cordless telephone operate near the Amateur 160-meter band, and a few of these may operate dangerously close to the low band edge.

Until now, there has only been a small trickle of cordless telephones into the United States. The Asian manufacturers anticipate a rush of orders from the United States when the FCC deregulation comes into effect this year. An executive of a large electronics company in Japan says, "We are currently negotiating for long-term orders until 1984, with quantities of up to 150,000 sets per year . . . The end of the Bell System domination will reflect the real demand in the U.S. market, but an FCC approval will always be a must for entry to the U.S. Market." Another manufacturer says, "Industrial sources say that the FCC plans to open new frequency bands, perhaps including UHF, for cordless telephone, so we shall do nothing until the position in the U.S. market is clearer."

Another manufacturer of telephones says, "We shall soon be shipping about 2,500 units per month to Radio Shack in the United States." The manufacturer breaks down sales of cordless telephones as 50 percent to the U.S., 40 percent to Italy, the U.K., and France, and 10 percent to South Africa. And finally, a Taiwan company says that U.S. buyers have asked them to expand production to handle orders of 150,000 units per month. A large proportion of the units produced will be of the "cordless" variety.

It is obvious that, with a good receiving antenna, an Amateur can hear these devices over a distance of a few miles. And on the other hand, will legitimate 160-meter Amateur operation cause interference to these devices?

As of today the number of cordless telephones entering the U.S. is but a trickle. What will happen in the next few years when the trickle becomes a flood? Will tomorrow's phones continue to use the "160-meter" channel? Or will they be switched to the UHF region? And what will happen when a kilowatt ham rig opens up on 160 meters? How many cordless telephones will it wipe out?

The cordless telephone falls under FCC *jurisdiction* as described in Part 15, Subpart D, of the Rules and Regulations. Paragraph 15.152 states that if a low-power communication device causes interference to another service, it must cease operation until the interference is eliminated. Fine words, but what can be done when the country is flooded with cordless telephones? There will undoubtedly be more to this story and it will be interesting to see in what portion of the radio spectrum these space-age devices will eventually find a home. The future of the cordless phone looks bright. Its relationship with other services in the radio spectrum, particularly the Amateur Service, is still an open question.

the 10-MHz Amateur (?) band

Listening to the so-called 30-meter Amateur band during the first few months of 1982 has been a frustrating experience. Amateur activity worldwide in the band has been quite low. For the first, heady days after January 1, quite a few stations were active on the band, notably English and Australian Amateurs. But, as the days dragged on, and U.S. hams were prohibited from using the band, interest lagged and now the band is sparsely occupied.

The star performer seems to be C6ABA on Abaco Island in the Bahamas. Gordon has been on the air almost daily, working every 10-MHz Amateur he can hear. Another outstanding signal that showed up in early February was DL2GG/YV5 in Venezuela. Many's the time his sharp CW signal has pinned the meter on my receiver. The two American beacon signals, KK2XJM (K4MB) and KK2XGH (N4DR), are on almost daily, and it is rumored that another, experimental, station may be on the band by the time this appears in print.

All in all, about seventy Amateur calls have been logged on the band, covering about twenty-five countries. A few "bootleggers" have been noted, but these pop on and off quickly and don't seem to be a problem. A few DX-minded 30-meter operators call "CQ 20" and listen for re-

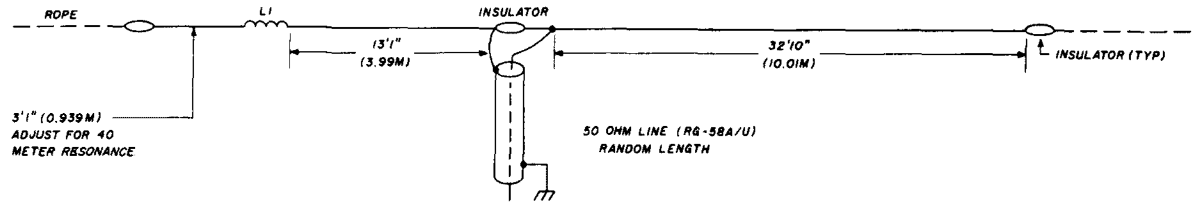


fig. 2. The JA3CZV two-band dipole for 40 and 15 meters, as revised by K6URI. Coil L1 is 115-1/2 turns No. 16e, 1 inch diameter, 6-3/8 inch winding length. Coaxial joint at center insulator should be waterproofed by wrapping of vinyl electrical tape covered by a coating of RTV sealant. (Note: make sure RTV is free from acetic acid to prevent corrosion — read the label!)

plies near 14,075 kHz. And many times the 30-meter ham will call CQ time after time with no reply.

While U.S. Amateurs are barred from the band, some activity goes on in this frequency span from the other services. Radio Moscow has an English-speaking station on 10,120 kHz, and there are a few RTTY stations sputtering away at various hours. In addition, there are some Mexican point-to-point SSB stations near the top end of the band that appear now and then.

By far the most interesting occupants of the 30-meter band are the "spook" stations. These signals, signing no calls, or signing fictitious calls, were plentiful early in the year. One or two on SSB read off five-digit number lists, one list being in German! Most of the spooks are on CW, sending lists of five-digit number blocks. One or two spooks, very loud ones, send code groups in Cyrillic characters — possibly Russian stations.

An intriguing group of spooks inhabit the high end of the assignment. They converse among themselves, and any self-respecting Radio Amateur would blush at the poor operating techniques these stations exhibit. Here's hoping they are not "ours"! Working at about 10 WPM, these spooks make a bumbling effort to contact each other. The signals are a good S7 with little fading, so the stations can't be far away, nor are they far from each other. But they call and call, send QSA?, and generally stumble about, generally not even establishing good contact. Finally, they give up and close down, or move elsewhere. One evening somebody (an Amateur?) moved on the frequency and broke the two spooks and asked QSA? This really disrupted things and the poor spooks had a terrible time getting their act together. So far as I know, this particular net spends plenty of time calling, but very little time transmitting any meaningful information. Perhaps they should try the long-distance telephone! (They disappeared from the band about mid-March.)

So there you are. The yet-to-be-used 30-meter Amateur band is a wasteland. Here's hoping it will soon be put to use by the Amateur Service! And that probably won't happen until the State Department and the FCC get their act together and release the frequencies. Don't give up hope (yet).

the 40-10 meter antenna revisited

Some time ago, I published the details of a Japanese antenna designed by JA3CZV for operation on 7 and 21 MHz (**fig. 2**). The original design[2] was said to provide good performance on the two bands. Essentially, it is a 40-meter dipole with one portion loaded to provide a 15-meter section isolated from the antenna tip by the coil. Mike, K6URI, tried this antenna and came up with a new set of dimensions that seem to provide improved performance. As shown in the illustration, this antenna provides an SWR below 1.9-to-1 over a 150-kHz range on 7 MHz. At resonance, the SWR is very close to unity. The resonant frequency is adjusted by changing the tip section, which can run from 2 ft. 7 in. (79 cm) to 3 ft. 3 in. (1 m). This adjustment depends upon the size of the antenna insulator used and the proximity of the antenna to nearby objects.

On 15 meters, the SWR runs below 1.8-to-1 over the range of 21,050 to 21,400 kHz, with the SWR at the resonant frequency very close to unity.

the new Radio Handbook

I'm pleased to tell you that the new, twenty-second edition of the *Radio Handbook* has been published by Howard W. Sams Co., Inc., 4300 West 62nd St., Indianapolis, Indiana 46268. It is available through the Ham Radio Bookstore and many distributors worldwide. This 1200-page, hardbound handbook covers communications from A to Z. The new edition includes up-to-date information on transmitting and receiving equipment and antennas of all types, and it is written in language you can understand. I think it is a *great* handbook! (I should. I'm the editor!) I hope you enjoy reading the new *Radio Handbook* as much as I enjoyed compiling it.

references

1. "Telephones: makers optimistic as U.S. permits imports for retail sales," *Asian Sources Electronics*, January, 1982, pages 10-38, 114-136, 200-208, 218-230. Published by Trade Media Ltd., Box 1786, Kowloon Central, Hong Kong.
2. William I. Orr, W6SAI, "Antennas — facts and fiction," *CQ*, December, 1978.

ham radio

HAM CALENDAR

July

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
W1AW Schedule October 25, 1981-April 24, 1982 MTWThFSSn = Days of Week Dy = Daily W1AW code practice and bulletin transmissions are sent on the following schedule: EST Slow Code Practice MWF 9 A.M. 7 P.M. TThSSn 4 P.M. 10 P.M. Fast Code Practice MWF 4 P.M. 10 P.M. TTh 9 A.M. TThSSn 7 P.M. CW Bulletins Dy 5 P.M. 8 P.M. 11 P.M. MTWThF 10 A.M. RTTY Bulletins Dy 6 P.M. 9 P.M. 12 P.M. MTWThF 11 A.M. Voice Bulletins Dy 9:30 P.M. 12:30 A.M. CST Slow Code Practice MWF 8 A.M. 6 P.M. TThSSn 3 P.M. 9 P.M. Fast Code Practice MWF 3 P.M. 9 P.M. TTh 8 A.M. TThSSn 6 P.M. CW Bulletins Dy 4 P.M. 7 P.M. 10 P.M. MTWThF 9 A.M. RTTY Bulletins Dy 5 P.M. 8 P.M. 11 P.M. MTWThF 10 A.M. Voice Bulletins Dy 8:30 P.M. 11:30 P.M. PST Slow Code Practice MWF 6 A.M. 4 P.M. TThSSn 1 P.M. 7 P.M. Fast Code Practice MWF 1 P.M. 7 P.M. TTh 6 A.M. TThSSn [illegible] CW Bulletins Dy 2 P.M. 5 P.M. 8 P.M. MTWThF 7 A.M. RTTY Bulletins Dy 3 P.M. 6 P.M. 9 P.M. MTWThF 8 A.M. Voice Bulletins Dy 6:30 P.M. 9:30 P.M.				**CARF CANADA DAY CONTEST** 1 **ARRL CRRL MIDWEST CONVENTION** [illegible] SK, Canada 1-3 1	2	**HANNIBAL ARC 2ND ANNUAL SPECIAL CERTIFICATE** The National Tom Sawyer Days celebration 3-4 ** **WEST VIRGINIA STATE CONVENTION** Jackson's Mill. Contact WA8BYU 3-4 **VENEZUELAN PHONE CONTEST** 3-4 3
BONFIELD, IL, CENTENNIAL CELEBRATION Commemorative Amateur Radio Station 4 ** **HIGH PLAINS ARC SPECIAL EVENTS STATION K7YPT** At [illegible] WY, starting 0000Z July 4 to 0000Z July 6 4-5 ** 4	5	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) 6	**WEST COAST BULLETIN** 9PM PDT 8PM PST [illegible] 7 7	8	9	**19TH ANNUAL INTERNATIONAL HAMFEST** At International Peace Gardens between Dunseith, ND, and Boissevain, Manitoba, at the Canadian pavilion on the north side of the Gardens. For information contact VE4OBGMD or AD0GAC 10-11 **SOUTH MILWAUKEE ARC SWAPFEST 82** At the American Legion Post 434, Oak Creek, WI. For more information contact South Milwaukee ARC, P.O. Box 102, South Milwaukee, WI 53172 10 **RACINE MEGACYCLE CLUB'S SPECIAL EVENT STATION W9UDU** W9UDU will be operating from the city of Racine's harbor during Salmon-A-Rama 10-18 ** **NITTANY ARC HAM FESTIVAL** For more information contact NARC, P.O. Box 614, State College, PA 16801 10 **TEXOMA ARC** Will operate K5GOD from Denison, TX, to commemorate the city's Western Days 10-11 ** **IARU RADIOSPORT** 10-11 10
BATAVIA HAMFEST by the Genesee Radio Amateurs. At Alexander Firemen's Grounds, Route 98, Alexander, NY. Contact Batavia Hamfest, c/o GRAM, Inc., Box 572, Batavia, NY 14020 11 **INDIANA STATE AMATEUR RADIO CONVENTION** In conjunction with the Indianapolis Hamfest and Computer Show at the Marion County Fairgrounds. Contact Indianapolis Hamfest, Box 11776, Indianapolis, IN 46201 11 **ANNUAL SOUTH DAKOTA HAMFEST** Sponsored by the Black Hills ARC at Surbeck Center, SD School of Mines & Technology, Rapid City, SD. For information contact WB0PLVA, Black Hills ARC, 4822 Capitol, Rapid City, SD 57701 10-11 **HAMFEST 82** Sponsored by the Maple Ridge ARC at Maple Ridge Fairgrounds, 30 miles east of Vancouver, BC. Contact Maple Ridge ARC, Box 292, Maple Ridge, BC V2X 7G2 10-11 11	12	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) 13	**HARRISBURG ANNUAL FIRE CRACKER HAMFEST** At the Shellsville VFW Picnic Grounds, Rte 22 [illegible] ARC [illegible] 14 **VENEZUELAN CW CONTEST** 14-15 14	15	**GLACIER WATERTON HAMFEST** At [illegible] Campground, East Glacier, MT. Contact AB7UDJ, [illegible] Ave., Havre, MT 59501 16-18 **EASTERN MICHIGAN ARC SPECIAL EVENTS STATION** For the 1982 running of the Port Huron to Mackinac Yacht Race. Contact K8DD 16-18 ** 16	**WAPAKONETE, OH, RESERVOIR AMATEUR RADIO ASSOCIATION** Will operate K8OYL from 1200Z July 17 to 9499Z July 18. For more information contact K8OYL 17 ** **NEW HAMPSHIRE FM ASSOCIATION FLY IN** 3rd largest electronic flea market, located at the Manchester Municipal Airport. Contact K1WPM or W1KGZ 17 **LANE COUNTY HAM FAIR** Oregon National Guard Armory, 2515 Centennial, Eugene. Contact WA7MOK 17-18 **A5 MAGAZINE WORLDWIDE SSTV DX CONTEST** 17-18 **INTERNATIONAL QRP CONTEST** 17-18 17
17TH ANNUAL WOOD COUNTY HAM-A-RAMA Wood County Fairgrounds, Bowling Green, OH. Contact Wood Co. ARC c/o S. Trons (SASE), P.O. Box 73, Luckey, OH 43443 18 **ZERO BEATERS ARC HAMFEST** Missouri's oldest hamfest. Washington, MO, Fairgrounds. Contact Rich Noelke, Rt. 2, 10 Richard Dr., Washington, MO 63090 18 **6TH ANNUAL HALL OF FAME HAMFEST** Nimishillen Grange, 6461 Easton St., Louisville, OH. Contact WA8SHP 18 **RANGE WIDE HAMFEST** Gunn Park, 5 miles north of Grand Rapids. Contact WD0AAF, 736 Crystal Springs Rd., Grand Rapids, MN 55744 18 **LAPORTE COUNTY SUMMER HAMFEST** County Fairgrounds, Laporte, IN. Contact P.O. Box 30, Laporte, IN 46350 18 18	19	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) 20	**WEST COAST BULLETIN** 9PM PDT 8PM PST 0400 UTC 21 21	22	**ARRL NATIONAL CONVENTION** Cedar Rapids, IA 23-25 23	**TREATY CITY ARA** Special Event Station of W8UM will be operated from the site of the Annie Oakley Days celebration. Contact T.C.A.R.A., Box 91, Greenville, OH 45331 24-25 **MT. BEACON ARC ANNUAL HAMFEST** Arlington Sr. H.S., Poughkeepsie, NY. For more information contact WA2ZCN (SASE) 24 **SKI COUNTRY ARC FIRST ANNUAL SWAPFEST** Colorado Mtn. College Bldg., 1402 Blake Ave., Glenwood Springs. Contact WA0BBI 24 **NOARSFEST** Lorain County Fairgrounds, Wellington, OH. Contact NOARSFEST, P.O. Box 354, Lorain, OH 44052 24 **RESERVOIR ARA** Will operate W8DN during the Celina Lake Festival. Contact W8DN, P.O. Box 268, Celina, OH 45822 24 ** 24
BALTIMORE RADIO AMATEUR TELEVISION SOCIETY'S BRATS Maryland Hamfest, Howard County Fairgrounds, about 15 miles west of Baltimore. Contact BRATS, P.O. Box 5915, Baltimore, MD 21208 25 **AMATEUR RADIO PUBLIC SERVICE ASSOCIATION** of St. Joseph County will hold its 4th annual Swap & Shop. Contact N8DDJ 25 **RADIO AMATEUR TRANSMITTING SOCIETY (RATS)** Nashville Hamfest Computerfest at Exhibition Hall, Nashville Municipal Auditorium. Contact RATS, P.O. Box 2892, Nashville, TN 37219 25 **HAMFEST WV'S "BIGGIE"** TSRAC Wheeling WV Hamfest. Contact TSRAC, Box 240, RD 2, Adena, OH 43901 25 **COUNTY HUNTERS CW CONTEST** 25-26 25	26	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) 27	28	29	**AMATEUR RADIO COUNCIL OF ARIZONA'S 32ND ANNUAL HAMFEST** Fort Tuthill Fairgrounds, Flagstaff. Contact W7WGW 30-31 30	**25TH REUNION OF VHF RADIO AMATEURS OF THE OKLAHOMA CENTRAL 6 METER CLUB** Send name, address, and present call to T. W. Stevens, W5VCJ. Reunion will be held at the same time as the Oklahoma City Ham Holiday 31 **TANK AUTOMOTIVE COMMAND ARC** WB8PW special events station to commemorate the 41st year of the Detroit Arsenal 31 ** **RADIO AMATEUR MEGACYCLE SOCIETY'S 20TH ANNUAL ILLINOIS QSO PARTY** Contact RAMS, K9CJU 31-Aug. 1 ** 31

*SEE COMING EVENTS

operation upgrade: part 8

The eighth part in a continuing series to help you upgrade your ticket

Previous articles of this series have explained in simple terms the fundamentals of linear devices in electrical circuits, active devices of several types (diode devices, triode devices, etc.), and a few simple radiotelegraph (CW) transmitters. In this article we will look at a variety of forms that radiotelegraph receivers might take.

A CW transmitter generates a radio frequency (rf) ac, usually amplifies it, controls it in such a way that it will transmit dots and dashes of rf energy (with a key), feeds the rf ac to an antenna, and radiates the rf energy into the atmosphere.

basic detector circuits

What can be done at a receiving point to make a radiated CW signal audible to a listener? Well, first we need a receiving antenna. With an antenna wire up in the air, any rf waves passing across it will induce an rf ac of their frequency into it. But what will make this received signal audible? How about a pair of earphones between antenna and ground, as in **fig. 1a**? No good. The only frequencies we can hear are between about 16 Hz and 20 kHz, but the lowest ham band frequency is 1.8 MHz. So, even with 1.8 MHz ac flowing in the earphones, the earphone's metal diaphragms cannot vibrate that fast, and we couldn't

By Robert L. Shrader, W6BNB, 11911 Barnett Valley Road, Sebastopol, California 95472

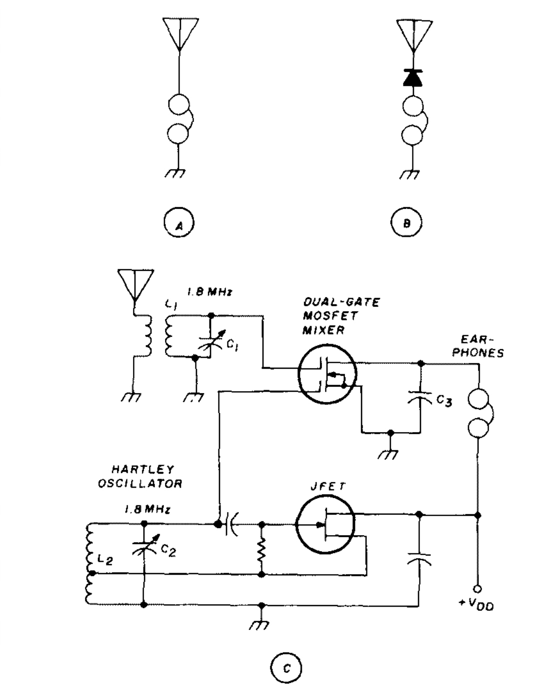


fig. 1A: Earphones in series between antenna and ground. B: Rectifying detector will not make CW signals readable. C: Heterodyne detector for CW reception.

hear it if they did. The earphones (or a loudspeaker) will need an ac of a frequency less than 20 kHz or a dc that is varying at a rate of less than 20 kHz for them to produce a sound wave that we can hear.

OK, let's try a diode in series with the earphones and antenna, as in **fig. 1b**. This gives us a rectified ac, or 1,800,000 pulses per second of dc flowing through the phones (assuming a 1.8-MHz signal being received). Can we hear these pulses? No, but this dc should be able to either pull in the earphone diaphragms a little or allow them to swing outward a little, depending on the polarity of the dc developed by the rectification. If the transmitted signal is being keyed, at the receiving point the earphone diaphragms might swing in and stay there until the signal stops, at which time they will swing back out again. We might hear this as weak clicks if the received signal is CW, but few of us could decipher what the clicks were saying. We need something that will produce some kind of a tone during the time the signal is being received, and none when the signal ceases. (This circuit *would* demodulate modulated signals.) Let's try heterodyning, or translating the 1.8 MHz ac down to some audio or audible frequency (af) that we can hear with the circuit shown in **fig. 1c**.

Now we are getting into the nitty gritty of a radio receiver. The antenna circuit consists of the antenna, the primary coil of the rf transformer, and ground. The secondary coil is tuned to the desired radio wave's frequency, 1.8 MHz in our case. When the tuned circuit is resonant to this frequency a maximum value of any received signal of this frequency will be fed to the upper gate of the dual-gate MOSFET mixer. (Both gates will affect the drain current, or I_D, flowing down through the earphones.) Below the mixer is a good old Hartley JFET oscillator that can be tuned across 1.8 MHz. Some of its rf ac is fed to the lower MOSFET gate. What is going to happen now? Well, if the input signal is 1,800,000 Hz and the Hartley is tuned to 1,801,000 Hz, then both of these frequencies will be affecting the I_D. As a result, the I_D has the following frequency components in it: 1.8 MHz, 1.801 MHz, 3.601 MHz (sum), and 0.001 MHz, which is 1000 Hz (difference frequency).

What effect will these four frequencies have on the earphones? Since the earphones cannot respond to the three radio frequencies, they can respond only to the 1000 Hz, which is a pleasant af tone for a listener (it should be heard as a pure sine wave tone). Actually C_3 is selected to act as an rf bypass or filter capacitor to prevent the three rf signals from getting to the earphones, but will have almost no effect on the lower audio frequency component. It might have a value between 0.0005 and 0.002 μF. What values might L_1, L_2, C_1, and C_2 have? You can figure this out from the resonant formulas given in Part 2 of this series. Consider the variable capacitors as having 100 pF at maximum, and compute the necessary inductance needed to resonate at the low frequency end of the 1.8-MHz band (1.8 to 2 MHz). (Sure sounds simple. Try it. Go ahead, we dare you!) If you determine this, then how much would the variable capacitor have to be reduced to tune to the 2-MHz bandedge?

Suppose the Hartley circuit is tuned to 1,799,000 Hz instead of 1.801 MHz. What do you think the earphones would respond with now? Since the received signal is still on 1.8 MHz it would beat against 1.799 MHz and produce a 1 kHz signal again. Right? What if the Hartley is tuned to 1.8005 MHz? Does 500 Hz agree with your computations? Again, this is a very pleasant tone to listen to. You will probably always tune your receiver to CW tones ranging from about 400 to 1000 Hz, unless you are trying to get away from QRM (interfering signals). Suppose the Hartley is also tuned to 1.8 MHz. What would you hear now? The answer is nothing, because the two signals are now zero beat. This means the beat difference is zero Hz, which cannot be heard, of course. Actually, as you tune across a CW signal it will first be heard as a high pitched whistle (3 to 10 kHz, depending on the

af filters in your receiver). As you continue to tune the tone descends lower and lower until a zero beat is reached. Past zero beat the tone will appear again and increase in frequency as you continue to tune until it is no longer audible. With this simple heterodyne, or beat detector, the tones on both sides of zero beat will be equal in amplitude. You could tune to either side of zero beat and copy a CW signal equally well.

We have used a dual-gate MOSFET as the mixer because it is one of the best, but you could also use the BJT mixer of **fig. 4** of Part 7, or a triode, or a pentode, or even a diode. So there are a lot of possibilities, but we have space to cover only a few of the basic ideas. If you worked the problems given two paragraphs above, did you come up with an L value of about 75 μH? And a reduction of C to about 80 pF? If you did not, how about trying them now?

a TRF receiver

The first really successful sensitive detector for CW signals was a simple triode VT Armstrong oscillator with earphones in the plate circuit. With an antenna coupled to the LC circuit and with the circuit in oscillation, beat tones could be heard in the earphones. However, when it was in oscillation it actually transmitted signals, sometimes for many miles.

Unfortunately, the simple detectors never produce a very loud signal in earphones or in a loudspeaker. What is needed is some amplification. If an rf amplifier is added between the antenna and the detector it does three things. (1) It amplifies any signal to which it is tuned. (2) It adds another tuned circuit which makes the receiver more selective. This means it can select one signal better out of several on nearby frequencies. (3) It prevents oscillations of an oscillating detector from being coupled into the antenna and radiating an unwanted signal.

An rf amplifier allows much weaker signals to be brought up to earphone volume, but the signals are still just at earphone volume. What is needed further is an audio frequency amplifier or two to make the detected signal strong enough to operate a loudspeaker. A block diagram of a possible tuned-radio-frequency (TRF) amplifier receiver is shown in **fig. 2.** If an autodyne (self-heterodyning) detector, such as the oscillating Armstrong, is used, then the local oscillator circuit shown dashed would not be necessary. The first variable resistor indicates an rf volume or gain control to prevent strong received signals from overdriving the detector. The second variable resistor is an af gain control to regulate how much signal is fed to the loudspeaker.

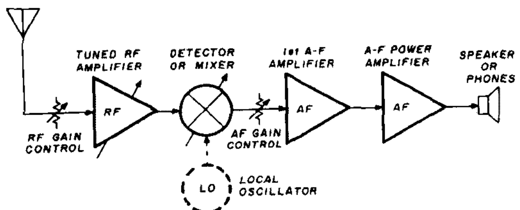


fig. 2. Block diagram of a TRF receiver for CW.

If the TRF is an all-semiconductor receiver, the rf amplifier might be a JFET or a MOSFET. The detector will be a dual-gate mixer or a JFET Armstrong oscillator with some means of controlling oscillation strength, and there will probably be two BJT stages of af amplification. If the TRF is an all VT receiver, the rf amplifier would be a pentode, the detector either a triode Armstrong oscillator circuit, or a pentagrid converter (mixer tube) with a triode or pentode Hartley local oscillator, followed by a triode first rf amplifier and a beam power tetrode as the af PA.

a CW superheterodyne

TRF receivers were the popular Amateur receivers of the early thirties. They are still a fairly good form of receiver for use in the LF, the MF, and in parts of the high-frequency spectrum. If the bands are not too crowded they can be used quite successfully up to at least 7 MHz. Above this they may not be sensitive enough and may be too broad to be very useful. What is needed is a receiver that has the same bandwidth (selectivity) and gain (sensitivity) on all of the Amateur bands. A double-heterodyne or superheterodyne (superhet) system answers these requirements.

A block diagram of a simple CW superheterodyne is shown in **fig. 3.** Can you see that if the 450-kHz i-f amplifier(s), second detector and BFO were left out you would have a TRF receiver? In a superheterodyne, signals from the antenna are amplified by the rf amplifier as in the TRF. But the signal into the first detector or mixer is heterodyned by a local oscillator and translated to a medium (MF), or intermediate frequency (i-f), of 450 kHz in this particular receiver (different frequencies are used as the i-f in different superhets). From here on the circuitry is similar to that of the TRF again. The 450-kHz i-f is fed to a 450-kHz mixer detector so that the second local oscillator, which *in this application is called a* beat-frequency oscillator (BFO), can produce an audio beat tone on CW signals, which can then be amplified as in the TRF.

The arrows through the high-frequency rf amplifier, the high-frequency mixer, and the high-frequency local oscillator symbols indicate that these three stages must be tuned for optimum operation. The dashes between arrows indicate that the tuning de-

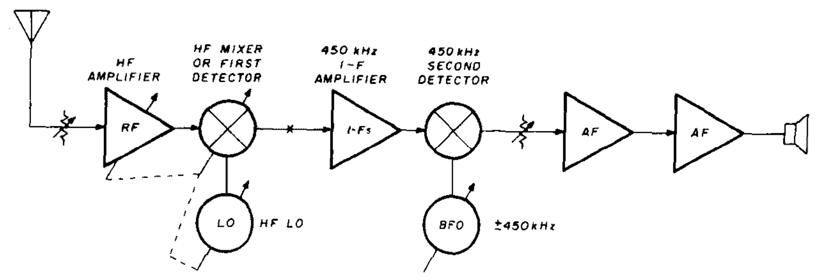


fig. 3. Block diagram of a superheterodyne for CW.

vices are all ganged (tuning capacitors are on a common shaft, for example). The 450-kHz i-f stages and the second detector are all fixed-tuned to 450 kHz and left that way. The beat-frequency oscillator might be tunable from about 447 kHz across 450 kHz to about 453 kHz in many superhets, and may be fixed tuned or switchable in others. The af amplifiers are untuned of course, although a low-pass or bandpass filter may be added before or after the af gain control to limit received signals to a maximum af of perhaps 500 Hz for CW (3 kHz for phone).

The big advantage of the superhet over the TRF is the i-f amplifier(s). Actually, there are usually two or more i-f amplifiers, all tuned to the same frequency, 450 kHz in our case. At 450 kHz the tuned i-f transformers can be engineered to provide a passband (bandwidth) of as little as 10 kHz, perhaps. The more tuned transformers (one in each i-f stage) the steeper the skirts of the passband developed. Since each of the i-f stages is an amplifier, a superhet will have much more gain or sensitivity than is possible with a TRF. Furthermore, the rf and first detector can be quite broad but the relatively narrow bandpass response of all of the i-f transformers sets the selectivity of the receiver to about 10 kHz regardless of which ham band is being received.

If a narrower passband is desired, a crystal bandpass filter may be added between the first detector and the first i-f, at the point marked X. If such a filter has a passband of 500 Hz, that will determine the maximum bandwidth of the receiver. Such a narrow passband is excellent for CW reception. The 10-kHz bandpass might be usable for a-m signals, but is really nearly twice as wide as the recommended 6-kHz limit for Amateur a-m transmissions. For SSB signals a bandwidth of 2.8 kHz is desirable.

If the input signal is translated to a 50-kHz i-f, amplifier bandpass can be decreased from 10 kHz to perhaps 3 kHz. Unfortunately this develops another difficulty called "images." If the received signal is at 7.1 MHz and a 50-kHz i-f strip is used, the local oscillator could be at either 7.15 MHz or at 7.05 MHz. At 7 MHz it is difficult to produce high gain rf amplifiers with 6-dB-down passbands much under 100 kHz. As a result, if the LO is at 7.15 MHz it will beat against the 7.1-MHz signal and produce a 50-kHz i-f as it should. But another Amateur transmitting on 7.05 MHz would also feed through the broad rf amplifier and mixer tuned circuits with only a little attenuation (reduction) and show up in the i-f channel also, be detected, and develop strong output signals in the loudspeaker. So, you would hear two loud signals at the same time. The undesired signal is always twice the i-f, or twice 50 kHz in this case, from the desired signal (7.1 MHz). It is called an image frequency signal, or just an image.

Let's go back to using 450 kHz as the i-f. If the desired station is on 7.1 MHz, then the LO frequency might be 7.1 + 0.45 MHz, or 7.55 MHz. Now, the image signal would be twice 0.45 MHz, or 0.9 MHz across the desired signal, or at 6.65 MHz. If there were a strong signal at 6.65 MHz (not an Amateur signal in this case), it might also be able to squeeze a little of its signal through the rf and mixer tuned circuits and develop a weak image in the i-f strip and in the second detector.

If an i-f strip is developed at 2.5 MHz or higher it will usually place any image frequency so far away (twice 2.5 is 5 MHz) that the front end (rf and mixer) LC circuits of the superhet will prevent almost any image signal from getting into the i-f strip and second detector. However, a 2.5-MHz i-f has a very broad passband, perhaps 30 to 40 kHz. It is possible to use a double conversion superhet, first using a 2.5 MHz i-f strip to eliminate images, then translating this signal down to a 50-kHz i-f strip and second detector to develop a narrow (3-kHz) passband.

Rather than fool around with double conversion and two different i-f strips, modern receivers may use a single 9-MHz i-f strip (which by itself would be very broad), but insert a narrow-band 4- to 8-pole (section) crystal filter just before the first i-f stage. Only signals which are accepted by the crystal filter with its narrow passband can reach the i-f amplifiers and

be fed to the second detector, regardless of how broad the i-f passband may be. The high frequency of the i-f prevents images, and the crystal filter ensures narrow bandwidth. By switching in different crystal filters the passband of the receiver can be changed from perhaps 200 Hz for CW, to 2.8 kHz for SSB, to 6 kHz for a-m, to 15 kHz for fm, and so on.

the beat-frequency oscillator

The operation of the BFO of a superheterodyne can determine how well signals will be received. Its duty is to beat against, or heterodyne, signals coming through the i-f strip to the second detector. The graph of **fig.** 4 shows a possible 2-kHz passband of a 450-kHz i-f strip of a superhet. Signals translated to exactly 450 kHz will pass through the i-f strip with maximum amplitude. Those 1 kHz to either side will be weaker by 6 dB (half the voltage). Signals 2 kHz from the center of the i-f passband will be very weak. It can be said that the passband response or bandwidth is 2 kHz at 6-dB down, or that the 6-dB passband is 2 kHz wide. At 60 dB down (one thousandth the voltage) it might be 20 kHz wide.

If the BFO is tuned to exactly 450 kHz, any CW signal tuned by the receiver front end to come in on the center frequency of the 450 kHz i-f strip would be at zero beat and nothing would be heard of it except possibly some clicks. If the front end were tuned 1 kHz higher or lower, the incoming signal in the i-f strip would be at either the 449 or the 451 kHz points, and the signal would be heard as a 1-kHz tone, but 6 dB weaker than it could be. To produce the loudest 1-kHz tone from the signal, the BFO should be tuned to 451 (or 449) kHz. Now, as the receiver front end is tuned so that the received i-f signal moves across the i-f strip from 449 to 451 kHz, the audible beat tone would change from a medium strong 2000 Hz signal to a strong 1000 Hz signal, and down to a zero beat. As the front end continues to tune past zero beat, the response of the beat tone frequency rapidly decreases on the other side of zero beat (shown by the rapid drop-off of the curve) and would be many dB weaker than the tones produced when the signal was between 449 and 451 kHz. If the skirts of the i-f filter were steep enough, the beat signals on the high side of 451 kHz might not be heard at all. This is called single signal reception. It prevents hearing each CW signal twice when tuning across them. You would hear them twice if the BFO were in the middle of the i-f filter frequency, and also twice with simple regenerative detectors, or with TRF receivers.

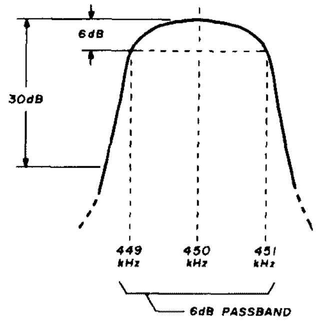


fig. 4. Possible response curve of a 450-kHz i-f strip.

receiver noise

The job of a receiver is to select some desired signal out of the millions of signals passing across its antenna, to amplify and detect just that one signal, and deliver it to a loudspeaker or earphones. Along with this signal there will be both external (picked up by the antenna) and internal (in the receiver) noises. The external noises, from lightning crashes (QRN), power leaks, opening and closing of electrical contacts nearby, and so forth are brought into the receiver by the antenna. If you disconnect the antenna and connect a resistor having an impedance the same as the rated impedance of the receiver input (50 ohms, for example), any noise you hear when you turn up the receiver gain controls must be generated in the receiver, mostly in the first rf amplifier and possibly some from the mixer. These are the most significant noises of a receiver because all other amplifier stages amplify them. Such internal noise is generated by random electron motions in the input stage resistors or in the first and perhaps the second active devices themselves. With an antenna on the receiver the relation of the received signal *power* to the noise *power* of the receiver is called the signal-to-noise ratio, or S/N.

The noise figure (NF) of a receiver is the ratio of the input S/N at the antenna input to the output S/N from the loudspeaker, or $NF = (S_i/N_i)/(S_o/N_o)$. In general, the narrower the bandwidth of a receiver the less noise that will be amplified, and the better the S/N and NF.

On the high-frequency Amateur bands, the external noises brought in by the antenna may completely mask the internal noises developed by the receiver itself, and will determine how weak a signal can be received adequately. On the VHF through microwave bands, there is usually little manmade and external noise and the internal noises generated at the input stages of the receiver determine how weak a signal can be picked up and made to produce readable output signals.

undesirable effects

Under high-gain operation of your receiver, a

strong nearby station 10 to perhaps 50 kHz away from the signal to which you are listening may cause desensitization of your receiver. Such signals are accepted by the broad front end and may produce a change in amplifier bias values, resulting in a lower received signal volume. Reduction of the rf gain control, or decoupling the antenna somewhat, will usually prevent or decrease such desensitization.

You may sometime be listening to a CW station on perhaps 7030 kHz. Up band at 7040 and 7048 kHz there are two other strong local stations in two separate CW QSOs with other stations. When they are both on the air at the same time their two signals push through the rf amplifier and into the mixer of your receiver and produce a beat at their difference frequency of 8 kHz down from 7040, or at 7032 kHz, which you hear as an audible tone. (You will also be able to hear them if you tune to about 7056 kHz.) Again, reduction of the rf gain will usually stop this type of interference. Remember, it is the fault of your receiver, not the fault of either of the two stations, which is producing interference for you.

the S-meter

Most Amateur receivers have an S-meter operating off the last i-f stage or the second detector stage to indicate the strength of received signals. The S-units are often calibrated in 6 dB steps (twice the voltage). An S4 signal should be 12 dB weaker (1/4 the input voltage) than an S6 signal. These meters may be fairly accurate on one band but rarely are correct on all of the Amateur bands. They do indicate in relative terms which signals are stronger and which are weaker. S-meters are calibrated in S-units from SØ to S9. An S9 signal would be 6 × 9, or 54 dB above the threshold of the noise generated internally in the receiver. A receiver should have the ability to adequately reproduce a received signal at least 40 to perhaps 50 dB over S9. It is said that such a receiver has a dynamic range of 96 or 106 dB.

Often, manmade noises will register as a steady S2 or S3 signal, making all signals weaker than this unreadable. In a very quiet location signals can often be copied which do not move the S-meter needle at all. The question then is, What kind of a signal report do I give these signals? Theoretically, an SØ should mean no signal strength at all.

Signal reports given by Amateurs are known as RST reports. The R stands for readability, from 1 to 5, with 5 being perfectly readable. The S stands for strength, from Ø to 9, with 9 being very strong. The T stands for tone, from 1 to 9, with 9 being a very pure tone. If there is some ripple in the power supply it may produce some hum modulation and would result in a T8 signal. Greater hum would be a T7. A T6 would be a slightly raspy tone. A T5 would be a very raspy tone, and so on. A 599 report is the best you can give. However, a 599C indicates chirpy keying. A 579 is an easily read relatively strong signal. A 499 indicates either there is interference, fading, or you cannot read the other operator because of poor keying. A 439 indicates most information *is being copied* but a rather weak signal. A 5Ø9 would have to indicate an extremely weak signal with no noise level, but 100 percent copyable.

You should always consider S-meter reports as approximations. In any case, it is not unusual for a signal to vary or fade up and down by five S-units in a few seconds. You can give either the peak S-meter reading as the report, or an average reading, but tell the other operator which report you are using. Most operators would prefer to hear the peak readings. They look much better in their log books.

FCC test topics

The following Novice test topics are discussed in this article, but should be understood by Technician/General and Advanced applicants also:

- vacuum tube applications and symbols
- quartz crystal applications
- block diagram of the stages of a simple receiver capable of A1 reception
- zero-beating a received signal
- RST signal reporting system

The following Technicial/General class FCC test topics are discussed in this article, but should be understood by Advanced class license applicants also:

- transformer applications and symbols
- frequency translation, mixing
- bandwidth
- decibels

The following Advanced-class FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

- detectors, mixer stages
- oscillators, applications
- receiver desensitizing
- signal-to-noise ratio
- rf and i-f amplifier stages

For additional information on these subjects you can refer to *Electronic Communication*, or to *Amateur Radio Theory and Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore.

ham radio

New channels may be added through the use of diode arrays

a digital approach to odd splits for the ICOM IC-2A(T)

The IC-2A(T) is a basic handheld 2-meter transceiver. Its features include both simplex and duplex modes with the standard ±600 kHz split, and in the 2AT a Touch Tone™ pad is included. Simplicity adds to ruggedness, and the unit takes care of 99 percent of the needs of most people.

But what about the need in certain locations to operate in a duplex mode that is neither ±600 kHz? How about those that have a need to operate MARS or CAP repeaters?

There are three basic requirements that must be met when modifying any handheld. First, whatever is added must be able to fit into the few crevices left when the unit is buttoned up without anything being smashed or bent grotesquely. Therefore mod "X" must be as small as possible.

Secondly, the modification must do only what it's supposed to do and no more. It must not interfere with the normal operation of the rig in any way not intended. This also means it should not unnecessarily restrict access for maintenance. Some apparently believe that once their mod is installed and working, the unit will never break.

Last, and most important, the mod must be simple. There is not much room to work in, and the risk of construction errors must be minimized.

This discussion covers the details involving the ICOM unit; however, the principle is easily adapted to other types if they use static BCD frequency entry.

theory of operation

A detailed block diagram of the PLL is shown in **fig. 1**. Controlling the frequency of the VCO is the divide-by-N chip IC1. Its inputs are generated by simple BCD thumbwheel switches, and the design of the PLL allows the value shown on the switches to equal the received frequency in megahertz. Of special interest is the switching arrangement for the PLL local oscillator. During receive the output of one crystal is used to mix with the VCO output, and the resulting intermediate frequency is fed to IC1. The result is that the VCO locks onto the receiver's first injection frequency divided by two. During transmit another crystal is switched to take the place of the first. This causes the PLL i-f to change frequency and the phase detector, upon detecting the change, sends an error voltage to the VCO, causing it to make up the difference caused by changing crystals. Shifting the VCO in this way allows the PLL to control the carrier frequency directly.

Changing crystals also offers a handy way to de-

By Jim Campton, N7AAD, 3001 South 288th, No. 182, Federal Way, Washington 98003

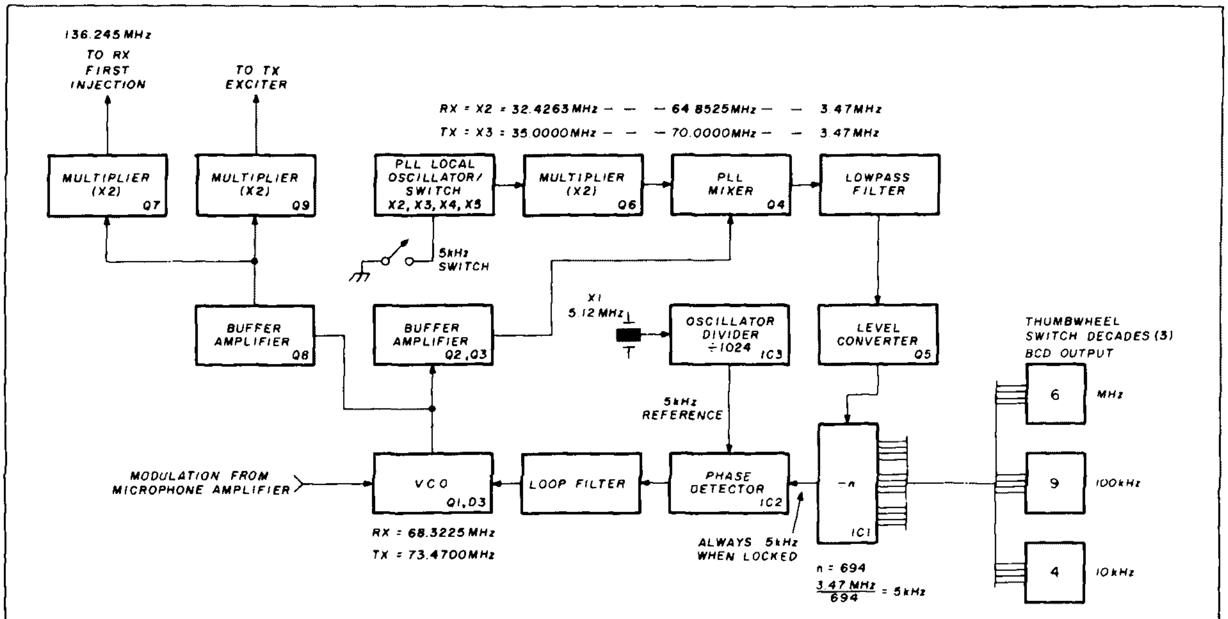


fig. 1. Block diagram of the PLL circuitry, which controls transmit and receive frequencies in the ICOM IC-2A.

rive the standard offsets from fixed thumbwheel switches without the added expense of CMOS adder circuits, since only two offsets are necessary. However, if an extra odd offset or two are needed, adding more crystals with their associated components is not the answer. Aside from being impractical, it is unnecessary since all that is required is to change the inputs of IC1 appropriately each time you want the VCO to change frequency.

Practically speaking, if the separation between a repeater's input and output frequencies is not 600 kHz, then chances are pretty high that the pair is not related to any other pair, making it unique. Thus you can wire the transmit frequency into the transceiver with a diode array leaving only the problem of switching.

IC1 has internal pulldown resistors on its inputs leaving any unconnected at a low or ground potential. If all the lines from the various arrays are OR-tied to each input, as shown in **fig. 2**, the transmit 5 volts and receive 5 volts can be used for switching any array at any time. (The thumbwheel switches can be treated as just another array.)

The *number* of new channels that can be added is limited by the size of the diodes, the skill of the technician and the means of switching available. I used an 8-pin dual inline package having four SPST switches. These can be used for other purposes besides switching diode arrays. Control of subaudible tone frequencies is just one possibility.

One of the switches will have to be used to control

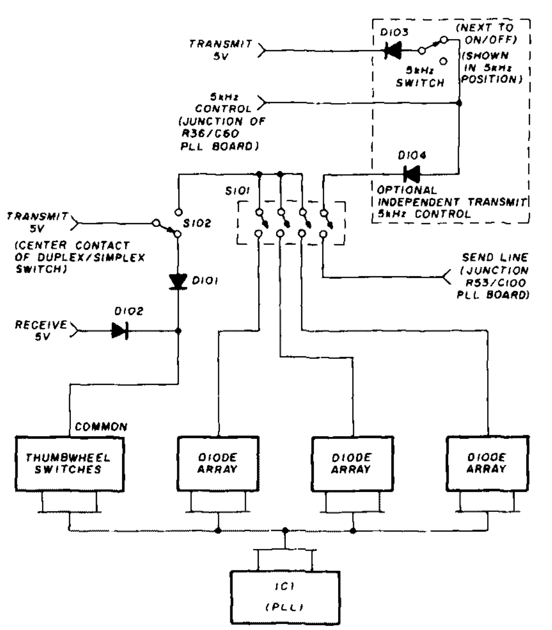


fig. 2. Diagram of the added circuitry. Inputs to IC1 in the IC-2A phase-locked loop are changed by switching in diode arrays to provide odd offset frequencies.

the 5-kHz digit on transmit, leaving the original switch to control 5 kHz in receive if the transmit and receive frequencies differ in the kilohertz digit, since the smallest step the PLL can synthesize is 10 kHz

without a change in the PLL local-oscillator frequency.

Fig. 3 shows the chart to convert the desired frequency into binary-coded decimal and a sketch representing the pins of IC1.

construction

Construction can be simple. However, adding more than one channel will require installation of an additional set of swtiches, which means putting a hole in the case. Such a project should be left to those who have, at minimum, a set of hand tools, clamps and a decent drill press. I used a miniature milling machine, an item to which not everybody has access; but with a steady drill press and a carefully made jig, holes of complex shape can be easily machined to close tolerances if the material to be used is soft.

Disassemble the transceiver by removing the four screws holding the battery plate using a No. 1 Phillips-head screwdriver. Then, using a No. 0 Phillips, remove the screws holding the case halves together. Remove the rear half and set it aside. Use caution when pulling the front since the microphone and speaker wires are attached and if the Touch Tone ™ pad is installed, further restriction is caused by the flex cable plugged into the main board. Carefully remove the plug and lay the front case half beside the chassis. Remove the two screws holding the chassis together with a No. 1 Phillips and unfold the chassis.

Locate IC1 on the PLL board. (The PLL board is the one without the big hole.) Desolder and carefully remove the flex board from its position over IC1. Remove the now unconnected pins from around IC1, one at a time, by clamping the free end and heating the foil side joint and pulling it through gently from the component side. After removal of the pins, be sure the plated-through holes are free of solder and debris.

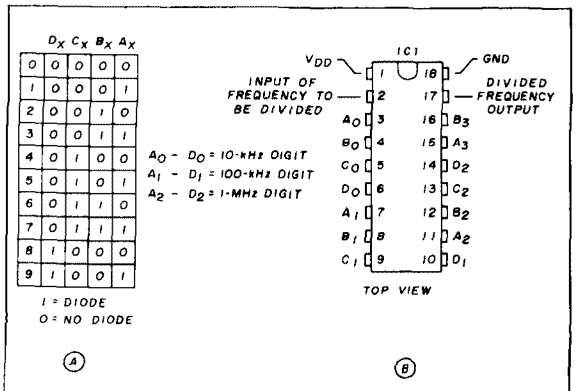


fig. 3. A: Matrix for converting decimal to BCD format. Sketch in B shows the function of the pins on IC1.

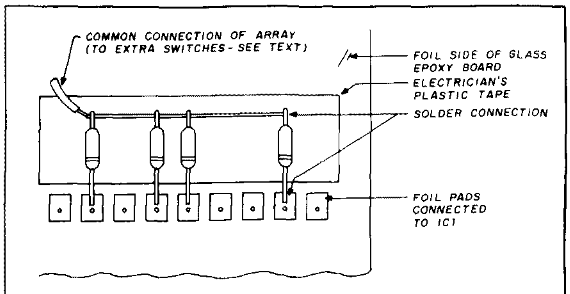


fig. 4. Example showing a diode array connected to IC1. The finished array is covered with tape, and the next array is installed over the first.

Next insert silicon diodes, such as 1N4148s, cathode-side down into the holes left by the pins. Solder the diodes as close to the board as possible. Next, thread the anode leads into the flex cable holes that will be over each diode when the cable is properly reinstalled. Each diode takes the place of one of the removed pins. Push the cable end firmly over IC1 and solder the leads after making sure that none are crossed. Bridge both gaps on the cable traces with solder.

Locate the thumbwheel frequency selector switches at the other end of the flex cable. The flex cable is reinforced by a thin phenolic board that is used as a stiff backing material for the soldered connections between the foil traces and the switch terminals. To this board is attached a green wire and either a brown or blue jumper. Cut or desolder the wire and remove it leaving nothing loose to accidentally short out.

If power were applied now the rig would operate normally in a range of 141.000 MHz to 149.995 MHz.

The thumbwheel switches have been wired to allow several diode arrays to be attached directly to the input leads of IC1 as shown in **fig. 4. Fig. 5** shows how to connect the arrays to the switches.

If more than one array has been installed or if the kilohertz digit must change during transmit, a hole must be cut in the rear case half to accommodate the switch package as well as the smaller hole necessary for the SPDT switch. **Fig. 6** outlines a method of cutting rectangular holes with a drill press. Cut a plywood block a little larger than the case and attach the plastic cover to the wood so that the drill bit in the press is perpendicular to the surface to be drilled when the block is resting on the smooth side of a larger piece of plywood that is attached to the press's table. Next nail a fence around the point where the bit's long axis intersects the plywood so that the fence's internal dimensions are equal to the dimensions of the small block, plus the dimensions of the DIP, minus the diameter of the drill bit to be used. A

1/16-inch (2-mm) drill bit is about as small as can be used without being too delicate. A smaller-diameter end mill is preferred. Only after lining up the table and practicing on scrap plastic to test the fit should an attempt be made to cut the cover.

Make the hole for S102 by using a high-speed drill and carving out a hole identical to the three already there. Using a sharp hobby knife, cut away a half circle in the top of the escutcheon plate to allow free movement of the switch when the case is installed.

One last detail is the antistatic modification to prevent accidental static discharge from damaging the rig. Typically the shortest path for static is through the serial-number plate and through the ungrounded

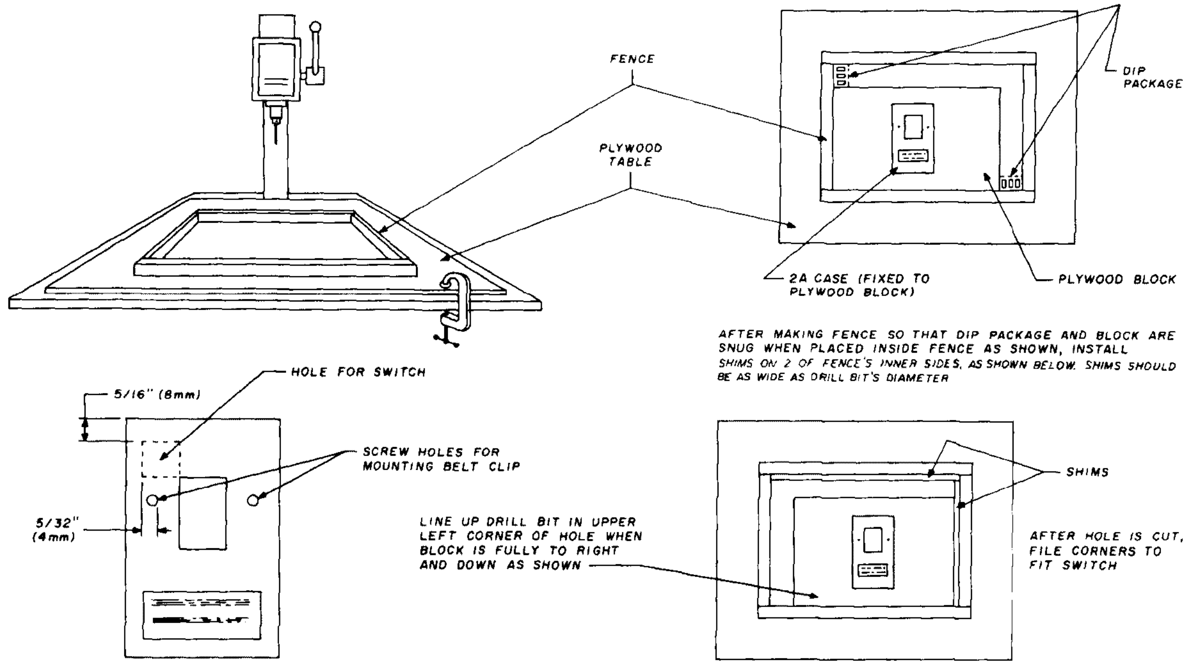


fig. 5. Illustrating the physical location of switches and arrays in the IC-2A.

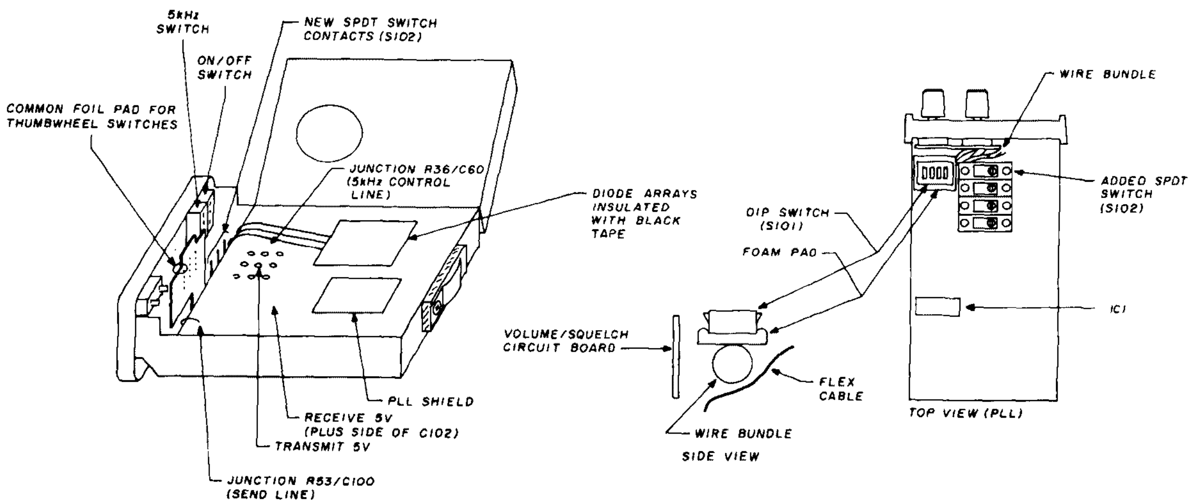


fig. 6. Equipment setup for cutting holes into the transceiver case to accommodate switches and diode arrays.

case of X3 where it disperses through the surrounding components, usually IC3 and/or Q8. The solution is to ground the case of X3 to either of the two transformer cans next to it by means of a solder bridge.

checkout and operation

It would be worthwhile to test the rig and give it a last visual inspection before reassembly. Check wires for clearance by gently closing the chassis and looking for obstructions. Connect a wattmeter, dummy load and frequency counter to the BNC connector on the top of the 2A. Connect the ground of the power supply to the braid of the coax and clip the positive lead to the battery terminal on the bottom. The supply voltage can be 6 to 11 volts with 8.4 volts being nominal. An ammeter may be used to learn much about what is happening inside but is not necessary.

Turn on the unit and check to see that it operates normally and then check to see if the modification performs as expected. If a fault is detected, check the wiring for shorts and the diodes for leakiness. Above all, use caution and think before acting. The 2A is no place to become reckless.

If operation is satisfactory, close the chassis and inspect closely for pinched wires before tightening the two chassis screws. Plug in the Touch Tone™ pad if present and lower the front half into place while making sure the speaker and microphone wires are not binding. Be sure the chassis PTT arm is not caught on a ledge and can touch the microswitch when depressed.

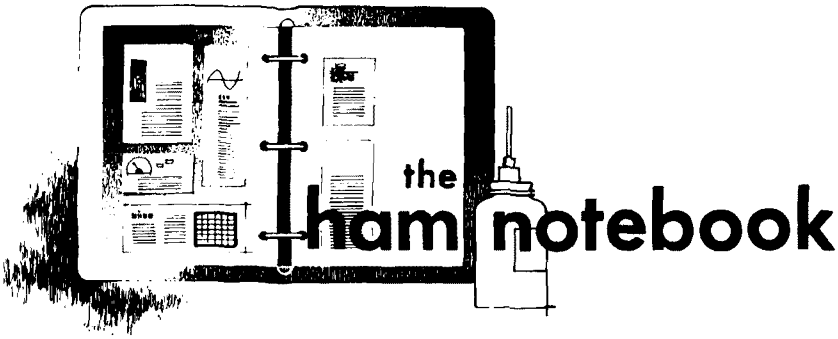
Put all the SPDT switches in their mechanical mid positions. Slide the plastic PTT lever into the grooves of the rear case half and fit it to the rig. When correctly installed, all the seams are together and the PTT lever operates correctly. When this state occurs, keep the case squeezed firmly together and install the battery plate on the bottom. Be sure to tighten the four screws firmly, but do not over tighten.

After installing the two side screws, give the unit one more checkout on the dummy load. Make sure all switches are fully to one side or the other.

conclusion

While spending a minimum of time and money you can enhance the value of your rig by adding up to four permanent memories that do not require any holding current. Furthermore, if only one or two channels are desired, the remaining two SPST switches can be used to control the frequency of a subaudible tone encoder. The possible combinations are limited only by the needs and the imagination of the individual. Successfully enhancing your rig sets you a step closer to the goal of perfect operation.

ham radio



CMOS timing circuit for frequency counters

This frequency-counter timing circuit uses CMOS ICs. It was inspired by a similar circuit using TTL ICs that appeared in an earlier issue of *ham radio*.[1]

When the article in reference 1 appeared, I was designing a frequency counter and I needed just such a circuit. However, the TTL circuit was of little use to me, so I created a CMOS version to meet my requirements. I thought that others might be interested in a CMOS version of this timing circuit, so here it is.

the circuit

My CMOS version is shown in **fig. 1**. Pulses of 10 Hz, which in my counter are derived from a LM5369 and a 4017 CMOS counter, are divided by six and enter one-half of a 4518 dual synchronous divide-by-ten counter. The 4518 divides by five by using the 1 and 4 binary-coded weighted outputs to provide a reset pulse through a 4011 two-input NAND gate. This action produces the 2-Hz output and performs the equivalent function of the 7490 divide-by-five counter.[1]

The divide-by-two portion of the 7490 is accomplished by a 4027 J-K flip-flop, IC5, which divides the 2-Hz output to 1 Hz. The other half of IC5 divides the 1-Hz signal to 0.5 Hz. The output of pin 15 of IC5B is used for the gate pulse.

operation

At this point my circuit differs in operation from Mr. Naslund's. Instead of inverting the 2-Hz pulse to generate the latch and reset pulses, the $\overline{\text{1-Hz}}$ and 1-Hz pulses are used for this purpose. By following the timing diagram, **fig. 2**, you can see that the latch pulse appears only when inputs A, B, C, and $\overline{D}$ are high at IC6A, and that this action occurs only at the end of the gate pulse.

By feeding the $\overline{\text{1-Hz}}$ input to the other four-input NAND gate (labeled IC6B) instead of the 1-Hz input, the reset pulse can be generated on the next 2-Hz pulse, well in advance of the next gate-enable pulse.

Note that, in my design, the latch and reset pulses are negative instead of positive-going. If desired, a 4082 dual four-input AND gate can be used instead of the 4012 to produce positive latch and reset pulses.

some advice

Don't use the 4017 or 4018 in place of the 4518, as they will not produce the proper duty cycle ratio for the 2-Hz waveform. Also, the 74C107 dual J-K flip-flop cannot be substituted for the 4027, since it isn't a positive edge-triggered device.

reference

1. R.S. Naslund, W9LL, "Counter Control Pulses," *ham notebook, ham radio*, April, 1980, page 70.

David H. Bevel

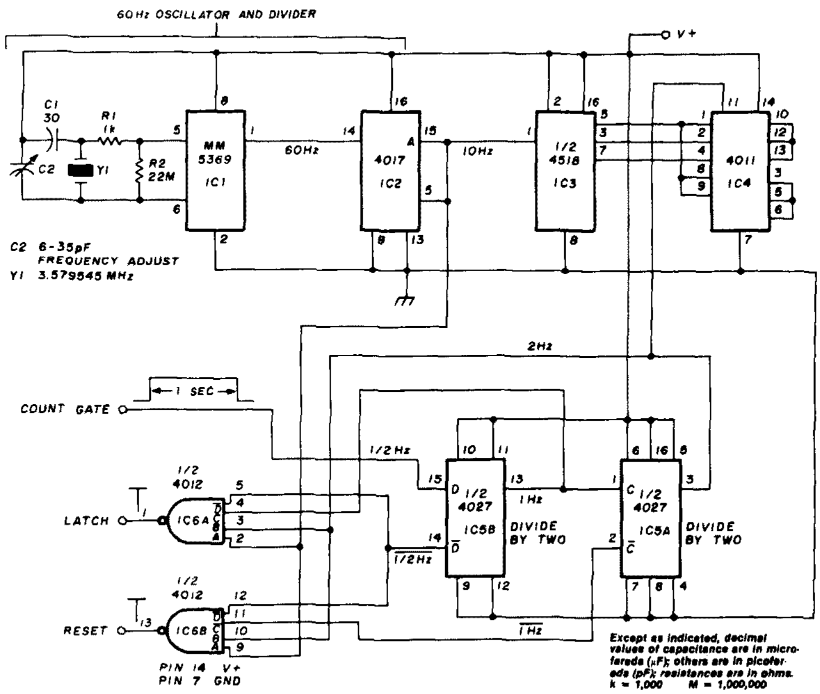
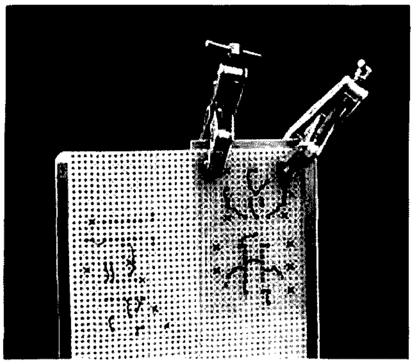


fig. 1. CMOS frequency-counter timing circuit inspired by a previous article in *ham radio*[1] using TTL devices.

printed circuit layout and drilling template

Neatness is not one of my natural abilities. As a result, some of my printed circuit board layouts have resembled my junkbox. Rather than give up, or spend hours laying out draftsman-quality boards, I devised the following fast, cheap, and neat method to do both the layout and drilling work. The wiring layout is made using a felt-tip marking pen on standard perforated board having holes on 0.1-inch centers (that's 2.5 mm for you metric fanatics). The orderly array of holes almost forces a neat appearance and matches the pin pattern of dual in-line package integrated circuits.



Perf board is used as a template for drilling PC boards.

The board is then clamped to the copperclad printed-circuit board as shown in the photograph. Once clamped, it is easy to drill through the circuit board using the perforated holes as guides. And the perforated board can be used to drill several circuits one at a time. I have not experienced any noticeable wearing on the perforated board from repeated use. In fact, after the circuit board or boards are drilled — and if I do not expect to make any more copies — I can merely erase the circuit layout from the perforated guide board and it is ready for use with another circuit. Making a photocopy of the template before erasing is an easy way to record the circuit. After the printed circuit board is drilled, I apply the resist pattern with a resist pen and etch the board with ferric chloride.

John M. Franke, WA4WDL

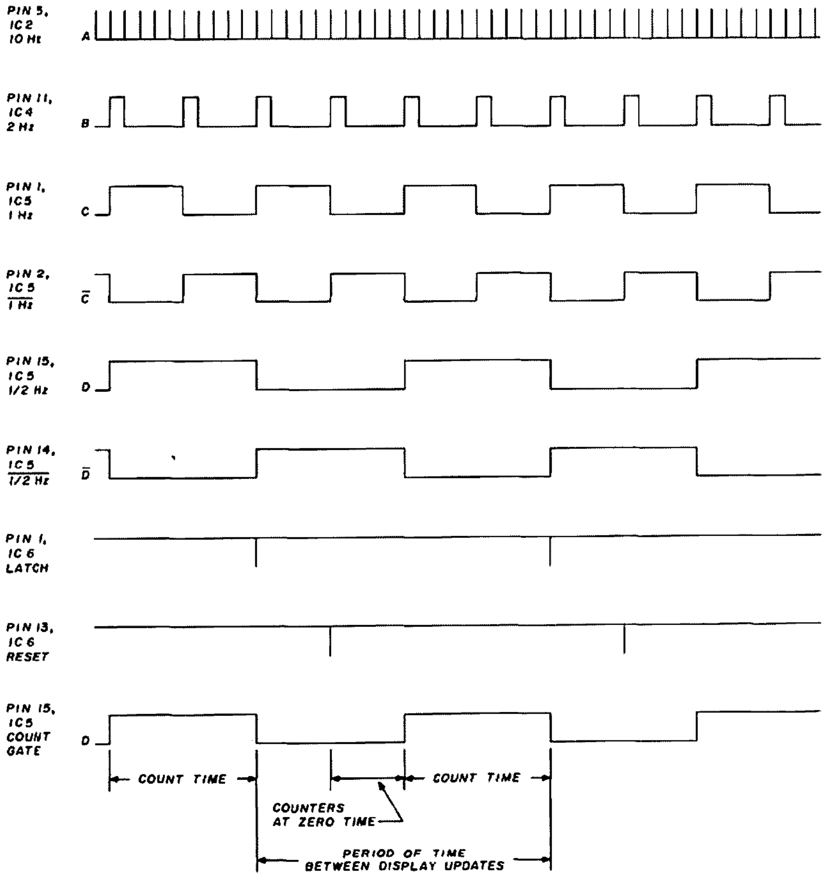


fig. 2. Timing diagram for the CMOS timing circuit.

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KNOW FIRST! Ham fanatics, you need The Pink Sheets — twice-monthly award-winning Hot Insider Newsletter! Ten pages, acclaimed best! Confidential facts, ideas, insights, news, technology, predictions, alerts! Quoted coast-to-coast! We print what you don't get elsewhere! $18.00 annually w/money back guarantee! Free sample — SASE (two stamps) W5YI, Box #10101-H, Dallas, TX 75207.

5VDC runs subassembly, decodes modulated/unmodulated CW. Both serial/parallel ASCII. Furnishes four control signals. $169. Telecraft Laboratories, Box 1185, E. Dennis, Mass. 02641.

OUR KEYERS turn difficult DX into logged contacts. SASE for information. Webco, Box 740211, Houston, Texas 77274.

MILITARY FM RADIOS and many accessories available. For free catalog send SASE to H. Ancerys Communications, PO Box 614, Antioch, CA 94509.

ICOM/KENWOOD owners. We have a newsletter for you. SASE please Users International Radio Club, 364H Kilpatrick Ave., Port St. Lucie, FL 33452.

KENWOOD TS180S complete w/Digital Memory system, CW and dual SSB filters, operating and service manuals, excellent. $600 or swap for Ten-Tec rig; Sony ICF-2001 digital AM/FM/SW scanning portable, $250. WA7ZYQ, 208-245-2070.

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box R802, Council Bluffs, Iowa 51502.

BUGBOOK I: (Logic and memory experiments) original edition for collectors, personalized autograph by author Dave Larsen, WB4HYJ $9.95 pp. Dave Larsen, 844 Hutcheson Dr., Blacksburg, VA 24060.

DON'T GET STRANDED! Battery Watchdog's alarm informs you of excess power drain. $19.95. J.F. Ratcliff, 3600 Meadow N., Renton, WA 98058. SASE brochure.

WANTED: Sinclair Black Watch. Complete, or as kit. Need not be working. Write with condition and price wanted to: C. Sarver, 256 West 88th Street, New York, NY 10024.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels; also "Skyrider Commercial", early transmitters such as HT-1, HT-3, HT-19, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

POLICE-FIRE-AIRCRAFT SCANNERS. Bearcat, Regency, BC-100 $298.99. Frequency Directories. Shortwave receivers. Sony, Kenwood, Yaesu, Panasonic. True discount prices and free UPS shipping in the continental U.S. Write: Galaxy Electronics, Box 1202, Akron, Ohio 44309.

YAESU OWNERS: Join your International Fox-Tango Club, now in its eleventh year. Calendar year dues still only $8 US, $9 Canada, $12 airmail elsewhere. Don't miss out, get 1982 top-rated FT Newsletters packed with modifications monthly, catalog of past modifications, free advertisements, technical consultation, FT net (Saturdays, 1700Z, 14.325 MHz), more. Go Fox-Tango! To join, send dues to FT Club, Box 15944, W. Palm Beach, FL 33406.

SATELLITE TV Low noise amplifier! Build for under $100. Satisfaction guaranteed. Detailed, easy to follow fourteen page instruction manual $7.00. XANDI, Box 25647, Dept. 23, Tempe, AZ 85282.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

FOR SALE: A complete Micor mobile radio, 25-50 MHz, with Systems 90 electronic siren and public address system. All equipment new, never installed. Comes with manuals, cables, covert antenna, 100 watt external speaker. Best offer. Write: Dean, P.O. Box 3403, APO New York, NY 09009.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

HAM-AD-FEST™ — Next 6 issues, $2.00. WA4OSR, Box 973, Mobile, AL 36601.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

SAFETY BELTS. $35.00 and up. Free information. Avatar Co., (W9JVF) 1147 · (H) N. Emerson, Indianapolis, IN 46219.

CONTESTERS: Package of programs designed for the ARRL DX, CQWW, CQWPX and IARU Radio Sport Contests produces scored, duped log, dupe sheet, QSLs and many valuable operator statistics. TRS-80 Model 1, 48k, 1 or more discs, MX-80 printer required. $89.95 plus tax non-refundable. Sample printout with SASE. P. Chamalian, W1RM, P.O. Box 1188, Burlington, CT 06013.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Williams, PO #7057, Norfolk, VA 23509.

VERY In-ter-est-ing! Next 5 Issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Visia, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

PURPLE HEART VETERANS: Organizing national Amateur Radio Chapter and Net to be affiliated with Military Order of the Purple Heart, Inc. For information and applications contact Clem Harris, KC5MM (ex WB5VDL), 6110 Pecan Trail Dr., San Antonio, TX 78249. (512) 699-1420.

BUY-SELL-TRADE. Send $1.00 for catalog. Give name, address, and call letters. Complete stock of major brands new and reconditioned amateur radio equipment. Call for best deals. We buy Collins, Drake, Swan, etc. Associated Radio, 8012 Conser, Overland Park, KS 66204. (913) 381-5900.

Coming Events

ACTIVITIES

"Places to go..."

ARIZONA: The Amateur Radio Council of Arizona will hold its 32nd annual Hamfest, July 30, 31, August 1, Fort Tuthill Fairgrounds, Flagstaff. Prizes, XYL activities, swapfest, transmitter hunt, speakers, forums, awards, entertainment on Friday and Saturday nights. Talk in on 147.870/147.270 portable repeater. Overnight camping available. For information: Wm. Oliver Grieve, W7WGW, 4301 N. 31st Avenue, Phoenix, AZ 85017 or call (602) 246-0200.

COLORADO: The Ski Country Amateur Radio Club's first annual Swapfest, July 24, 9 AM to 5 PM, Colorado Mountain College Building, 1402 Blake Avenue, Glenwood Springs. Admission $3.00. Tables $5.00. Flea market, commercial exhibitors, door prizes and refreshments. Talk in on 146.07/.67. For information: Frank WAØBBI, PO Box 280, El Jebel, CO 81628.

DELAWARE: The seventh annual New Delmarva Hamfest, Sunday, August 15, Gloryland Park, Bear. (5 miles south of Wilmington). Admission: $2.25 advance, $2.75 gate. Tailgating $3.50. Some tables available or bring your own. Refreshments available. First prize: Atari® Home Video Game system. Many other prizes. Talk in on 52 and 13/53. For info and a map SASE to Stephen Momot, K3HBP, 14 Balsam Rd., Wilmington, DE 19804. Make checks payable to Delmarva Hamfest.

FLORIDA: The Greater Jacksonville Hamfest Association's ninth annual Hamfest and ARRL Convention, August 7 and 8, Orange Park Kennel Club. FCC exams Friday, August 6 at Hamfest site. Apply to Atlanta FCC office ASAP. Hotel information: Jim Canfield, KD4CG, 996 Dostie Cir., Orange Park, FL 32073. Advance registration $3.50 from Robert J. Cutting, W2KGI, 1249 Cape Charles Avenue, Atlantic Beach, FL 32233. Door registration $4.00. Swap tables $12 per table both days through Andy Burton, NX4G, 5101 Younis Rd., Jacksonville, FL 32218. Talk in W4IZ on 146.16/.76 and 146.077/.67.

ILLINOIS: The Fox River Radio League again hosts the Illinois State ARRL Convention as part of its annual Hamfest at the Kane County Fairgrounds, St. Charles, Illinois, August 22. Commercial exhibits, flea market, demonstrations, contests, forums, and hot food. Exhibitors, dealers, and vendors contact: G.R. Isely, WD9GIG, 736 Fellows Street, St. Charles, IL 60174. Tickets $2.00 advance, $3.00 at gate. For advance tickets send SASE: J. Dubeck, KA9HQY, 1312 Bluebell Lane, Batavia, IL 60510.

INDIANA: The LaPorte County Summer Hamfest, Sunday, July 18, County Fairgrounds, LaPorte. Good food, cold drinks and indoor selling area. Information and reservations: PO Box 30, LaPorte, IN 46350.

MARYLAND: The Baltimore Radio Amateur Television Society's BRATS Maryland Hamfest, Sunday, July 25, Howard County Fairgrounds, about 15 miles west of Baltimore. Indoor tables with a/c power $15 each; without a/c $10 each. Indoor tailgating $5 per space, outdoor $3 per space. Overnight RV hookups available. For information and reservations: BRATS, PO Box 5915, Baltimore, MD 21208.

MICHIGAN: The Black River Amateur Radio Club's 29th annual Southwestern Michigan VHF Family Picnic, Sunday, August 1, West Side County Park near Glenn. Registration only $1.00. Flea market space available. Pack your lunch and beach gear. For information: Ed Alderman, KI8Z, RR #2, Box 44, Lawrence, MI 49064.

MICHIGAN: The Amateur Radio Public Service Association of St. Joseph County will hold its 4th annual Swap and Shop, July 25, St. Joseph County Fairgrounds, Centreville. Doors open 8 AM. Tickets $2.00 advance, $3.00 gate. Indoor tables $2.00. Free trunk sales. Camping available, Saturday night only, $6.00. Talk in on 146.52. For information: Dennis Cutler, N8DDU, 3051 Z Avenue, Vicksburg, MI 49097.

MINNESOTA: Range Wide Hamfest, July 18, 10 AM to 4 PM, Gunn Park, 6 miles north of Grand Rapids. Prizes. Admission and tables free. Camping available. Talk in on 52 and 146.28-88. For information: Bob, WDØAAF, 736 Crystal Springs Road, Grand Rapids, MN 55744. (218) 326-2268 evenings.

MISSOURI: The Zero Beaters Amateur Radio Club's Hamfest, Missouri's oldster, Sunday, July 18, Washington Mo. Fairgrounds. Call in on Washington repeater 147.84/24. For information: Rich Noelke, Rt. 3, 10 Richard Dr., Washington, MO 63090.

MISSOURI: The St. Charles Amateur Radio Club's Hamfest '82, August 22, Wentzville Community Club. Prizes, contests, flea market, food and fun for all. Admission $1.00 per car. Advance tickets $1.00 each, 4/$3.00. Door $1.50 each or 4/$5.00. For tickets and information: SCARC Hamfest 82, c/o Mike McCrann, WDØGSY, 25 Elm St., St. Peters, MO 63376.

MONTANA: The 50th annual WIMU Amateur Radio Convention, August 6, 7 and 8, West Yellowstone Convention and Civic Center, West Yellowstone. Tech forums, transmitter hunts, CW contest, OSCAR, computers, swaps, dealers, treasure hunt, Chinese auction, bingo, ladies/kids activities. Saturday night banquet, entertainment and more. Talk in on 34-94, 28-88 and 3935 kHz. For information call Ron Moss, K7ENE. (208) 356-3742, Rexburg, ID.

MONTANA: The Glacier-Waterton Hamfest, July 16, 17, 18, Three Forks Campground, East Glacier. Pre-registration prior to July 1, $8.00. On site registration $9.00. Prizes include Azden PCS 3000 2m rig, Swan VHF SWR wattmeter and many more. Live music, bazaar, dealers, bingo, crafts, auction, ladies activities. Send registration to Beverly Nord, WB7UDJ, 1540 Fifth Avenue, Havre, MT 59501. Make checks payable to Glacier-Waterton Int. Hamfest.

NEW HAMPSHIRE: Fly-in to New Hampshire's 3rd largest electronic flea market sponsored by the New Hampshire FM Association, Saturday, July 17, Manchester Municipal Airport, 9 AM. Admission $1.00. Sellers $5.00 tailgate or own table. Refreshments available. Door prizes. Talk in on 146.52 FM and 124.9 AM. For information: Dick DesRosiers, W1KGZ (603) 668-8880 or Doug Aiken, K1WPM, 30 Meadowglen Dr., Manchester, NH 03103 (603) 622-0831.

NEW YORK: The Mt. Beacon Amateur Radio Club's annual Hamfest, July 24, 8 AM, Arlington Senior High School, Poughkeepsie. Admission $2.00 (XYL and your kids free). Tailgating $3.00 (1 free admission), table $4.00 (1 free table and admission). Free flea market tables indoors, door prizes, auction, refreshments. Talk in on 146.37/.97 and 146.52 simplex. For information, tickets, registration SASE to Walt Cotter, WA2ZCN, North Hillside Lake Road, Wappingers Falls, NY 12590 (914) 226-6636.

OHIO: The 17th annual Wood County Ham-A-Rama, Sunday, July 18, Wood County Fairgrounds, Bowling Green. Free admission and parking. Prize drawing tickets $1.50 advance, $2.00 gate. Trunk sales space available. Refreshments. Gates open 10 AM. K8TIH talk in on .52. For information: SASE to Wood Co. ARC, c/o S. Irons, PO Box 73, Luckey, OH 43443.

OHIO: NOARSFEST, Saturday, July 24, Lorain County Fairgrounds, Wellington. Donations $2.50 advance, $3.00 gate, children under 12 free. Admission ticket good for prize drawings. Flea market space $1.00 per car. Indoor exhibits. Refreshments available, 807's furnished by NOARS. Free overnight camping Friday, no hookups. Mobile check-in prizes til 1:00 PM. Mobile check in K8KRG, 146.52/52. Directions and information on 146.10/70. For tickets: NOARSFEST, PO Box 354, Lorain, Ohio 44052.

PENNSYLVANIA: The Mid-Atlantic Amateur Radio Club's annual J.B.M. Hamfest, Sunday, August 8, 9 AM to 4 PM, rain or shine, Route 309 Drive-In Theater, Montgomeryville. Tailgate setup 8 AM. Admission $2.50 plus $1.00 additional for tailgate space. Non-licensed XYLs and children free. Refreshments, raffles, door prizes and more. Talk in on WB3JOE/R, 147.66/06 or 146.52 simplex. For information: Mid-Atlantic ARC, PO Box 352, Villanova, PA 19085.

PENNSYLVANIA: The 45th annual South Hills Brass Pounders and Modulators Hamfest, August 1, 10 AM to 4 PM, South Campus, Community College of Allegheny County, Pittsburgh. Admission $2 or 3/$5. Computers, OSCAR and ATV demos, Flea Market. Talk in on 146.13/73 and 146.52. For information: Andrew L. Pato, WA3PBD, 1433 Schauffler Drive, West Homestead, PA 15120.

PLAYBOY RESORT at Groat Gorge, McAfee, NJ — the place to relax and enjoy — see all the manufacturers' and dealers' exhibits — attend the vital and informative forums — renew old acquaintances and make new ones — all at the ARRL Hudson Division Convention, October 30-31. Send SASE now for complete details to HARC, Box 528, Englewood, NJ 07631.

TENNESSEE: The Radio Amateur Transmitting Society (RATS) will sponsor the Nashville Hamfest-Computerfest, Sunday, July 25, Exhibition Hall, Nashville Municipal Auditorium, James Robertson Parkway, Nashville. Indoors and air-conditioned. Doors open 8 AM. Admission $3.00. Refreshments. Talk in on .34/.94. For information: RATS, PO Box 2892, Nashville, TN 37219. (615) 459-2636 days. In Nashville 254-0088.

OPERATING EVENTS

"Things to do..."

JULY 10-11: The Texoma Amateur Radio Club will operate K5GQD from Denison, Texas, to commemorate the City's Western Days celebration. 1400Z, July 10 to 0100Z, July 11 and 1400Z to 2300Z, July 11. 80 thru 10 meters, lower end of the General phone bands. Certificate available for large SASE or 40C postage from K5GQD, 1303 E. Richards, Sherman, TX 75090.

JULY 10-18: The Racine Megacycle Club will operate W9UDU, a special events station during Salmon-A-Rama. W9UDU will be operating from the City of Racine's harbor. During the fishing contest, Racine is known as the Salmon Capitol of the World. 1100Z to 2300Z, July 10, 11, 17, 1100Z to 2000Z, July 18. Frequency: General portion of phone bands on 10, 15 and 20 meters. Go fishing for W9UDU and receive a special QSL. SASE to: W9UDU Racine Megacycle Club, c/o American Red Cross, Lakeshore Counties, 4521 Taylor Avenue, Racine, WI 53405.

JULY 16-18: The Eastern Michigan Amateur Radio Club will sponsor a special events station for the 1982 running of the Port Huron to Macinac Yacht Race; Friday, July 16 from 6 PM to 10 PM EDST; Saturday, July 17 and Sunday, July 18 from 10 AM to 10 PM EDST. SSB frequencies — 10 kHz inside lower edge on 75, 40 and 15 meter General Class phone bands. CW = 10 kHz inside lower edge of Novice bands. Two stations on SSB and one on CW are planned. For an 8" × 10", two-color certificate available for those contacting this station send business SASE to: K8DD, 1640 Henry, Port Huron, MI 48060.

JULY 17: The Wapakoneta, Ohio Reservoir Amateur Radio Association will operate K8QYL from 1300Z, July 17 to 0400Z, July 18 and again from 1300Z to 1900Z, July 18, from the birthplace of Neil Armstrong, tha first man on the moon. Frequencies: Phone 3940, 7260, 14285, 21360, 28590 ± QRM. CW — 50 kHz up from bottom of the band at the beginning of the odd hours. Check-ins invited on K8QYL/R on 147.93/147.33. Certificate for QSL and SASE to: K8QYL, PO Box 268, Celina, Ohio 45822.

JULY 24-25: The Treaty City Amateur Radio Association will operate W8UMD as a special event station from the site of the Annie Oakley Days celebration, 1600Z, July 24 to 1600Z, July 25. W8UMD will operate 10 kHz up from

bottom of the General band on 40 and 20 meters and will venture into the 40 meter Novice band occasionally. For a special certificate send business SASE and QSL to T.C.A.R.A., Box 91, Greenville, Ohio 45331.

JULY 24: Celina, Ohio, Reservoir Amateur Radio Association will operate W8DN from 1300Z to 1800Z from the Court House Lawn during the Celina Lake Festival. Frequencies: Phone — 3940, 7260, 14285, 21360, 28590 ±QRM. Check-ins invited on WB8FNB/R on 146.01/146.61. Certificate for QSL and SASE to: W8DN, PO Box 268, Celina, Ohio 45822.

JULY 31: The Tank-Automotive Command ARC will operate W8JPW to commemorate the 41st year of the Detroit Arsenal, home of the nation's first defense plant and the US Army Tank-Automotive Command. Frequencies: Phone 7.250-7.275; 21.400 and 148.55. Send 9 x 12 SASE for unfolded certificate to: W8JPW, US Army Communications Command, CCNC-TAC-M, 28251 Van Dyke, Warren, MI 48090.

JULY 31-AUG. 1: The Elmira area Amateurs will operate W2ZJ from Chemung County's 1st annual Good Neighbor Festival, 1300Z, July 31 thru 2100Z Aug. 1. Frequencies: 30 kHz up from lower edge of General phone band on 20, 40 and 80 meters. Send large SASE for a special certificate to A.R.S. W2ZJ, General Delivery, Elmira, NY 14904.

JULY 31 & AUGUST 1: The Green Mountain Wireless Society will be sponsoring a special event station to celebrate Calvin Coolidge's inauguration and to allow stations the opportunity for a Vermont contact. N-1-VT will operate from Calvin Coolidge State Park in Plymouth, Vermont, on 80 through 15 meters 10 kc up from bottom of the General portions of CW and phone bands. Novice 10 kc up from bottom of each band. For a certificate confirming QSO send large SASE to GWMS, PO Box 84, Rutland, VT 05701 by September 1, 1982.

JULY 31-AUGUST 4: VE3SAS Salvation Army Scouts will operate from Camp Madawaska, Victoria Lake, Northern Ontario, 80 to 10 meters, phone and CW, looking for other Boy Scouts stations. A special QSL card is available for contacts and SWL reports. SASE, 2-IRCs to VE3FOI, Dave Digweed, 12 Frederick Street, St. Catharines, Ontario L2S, 2S2, Canada.

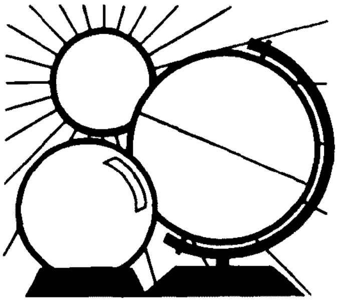
JULY 31-AUGUST 1: The Radio Amateur Megacycle Society's 20th annual Illinois QSO Party. 1800Z July 31 to 2300Z August 1. Rest period 0500Z to 1200Z, August 1. All bands, CW and phone. Same station may be worked on each band and mode. No repeater contacts. Frequencies: Any frequency but look about 60 kHz from low end on CS; about 3975, 7275, 14275, 21375 and 28675 on phone and about 25 kHz from low end of each Novice band. Exchange RST and county, Illinois stations. All others RST and state or province or country. Send entries no later than September 15, 1982 to RAMS/K9CJU, 3620 N. Oleander Ave., Chicago, IL 60634. Include business SASE for results.

AUGUST 1-8: The Niagara Peninsula ARC will operate a special event station to help celebrate the 100th anniversary of the Royal Canadian Henley Regatta. VE3ROW will operate all bands 160-10 meters. For a special QSL, send log data to: VE3ROW, c/o NPARC, PO Box 692, St. Catharines, Ontario, Canada L2R 6Y3.

AUGUST 13-15: The Alliance (Ohio) Amateur Radio Club will be exhibiting emergency radio communications during Carnation Week at Silver Park. The public is invited to watch club members demonstrate their skills in this type of communications.

AUGUST 14-16: The Englewood Amateur Radio Association invites all Amateurs to participate in the 23rd annual New Jersey QSO Party. 2000 UTC Saturday, August 14 to 0700 UTC, Sunday, August 15. 1300 UTC Sunday, August 14 to 0200 UTC, Monday, August 16. Phone and CW considered same contest. Contact a station once on each band; phone and CW considered separate bands. No CW contacts in phone band segments. NJ stations may work other NJ stations, call "CQ New Jersey" or "CQ NJ". New Jersey stations identify by "DE NJ" on CW and "New Jersey calling" on phone. Suggested frequencies: 1810, 3535, 3900, 7035, 7135, 7235, 14035, 14280, 21100, 21355, 28100, and 28610. Suggest phone on even hours; 15 meters on odd hours; 160 meters at 0500 UTC. Exchange QSO number, RST and QTH. New Jersey send county for QTH. Send logs and comments to: Englewood ARA, PO Box 528, Englewood, NJ 07631-0528. Include #10 SASE for results.

AUGUST 21-22: The Huron County Amateur Radio Club will celebrate the 169th anniversary of the Battle of Lake Erie by operating from Perry's Victory and International Peace Memorial on South Bass Island in Lake Erie. WA8HUR will be on the air beginning 1000Z, August 21 to 0000Z, August 22. SSB frequencies: 3910, 7250, 14280, 21360 and 28550 kHz. CW at 40 kHz up from bottom of each HF band. Novice station at 3720 kHz and 7115 kHz. FM on 146.52 MHz. For a special QSL card after making a contact, send QSL and SASE to ARS KF80.



DX FORECASTER

Garth Stonehocker, KØRYW

the summer ionosphere

The ionosphere is produced by ultraviolet radiation from the sun ionizing the constituents of the air in the D (80 km) and E (100 km) regions, and on up to about 180 km. The F region (250 km) is usually ionization moved along the geomagnetic field from elsewhere, mainly diffused up from below.

In our hemisphere, ion production is maximum in these D and E regions during the summer months. Remember that the sporadic E season (lots of ionization) is in the summer. Absorption and attenuation of signals in the lower frequency (40-160 meter) bands is the result of ionization in the D region, limiting propagation to 200-400 km during the day but then opening up to 2000 km at night. (The 200 km is in the summertime, the 400 km in the winter.)

The higher frequency bands (10-20 meters) are not much affected by increased summer absorption of signals because those frequencies are so high. But these bands have lower maximum usable frequencies (MUFs) in summer than winter, since the ionization is down lower. A good rule of thumb is that ionization is maximum either in the lower regions or upper regions but not both. Making up for lower MUFs, the longer hours of daylight in summer give more of the day with fairly high MUF. A flat-broad peak to the summer diurnal curve is seen, instead of the high-pointed peak of winter.

The solar flux value derived from measurements at 2800 MHz at Ottawa, Canada, is not ideal, because that frequency is not best for measuring the sun's ultraviolet radiation — but it's adequate. The readings date back to 1947 and can provide some useful sun-earth relationships (including substitute for sunspot number, SSN). And we use it as a daily solar predictor. The flux value is proportional to signal attenuation and E region MUF, and to the F region MUF after a time lag of two to three days. The Space Environment Service Center (SESC) in Boulder, Colorado, collects and broadcasts this information on WWV at 18 minutes after each hour. We hope they weather the budget cuts enough to continue. *Please write them!*

When is the flux/SSN really going to fall distinctly? The envelope of the superimposed curves of the past four to eleven years leads me to expect a drop from the eleven-year cycle peak of 200/140 monthly average. I expect it to hit 150/100 around October. We will see MUFs slowly decrease about twenty percent at mid latitudes in that same period of time. This will begin to change some of our DX operating habits. More later.

last minute forecast

The lower frequency bands (40 through 80 meters) are expected to offer good DX the first week and last few days of the month. The higher bands (10-20 meters) will improve to an excellent DX rating about the 18th to 20th of July. Disturbed days can enhance the rare DX openings about the 1st, 12th, 20th, and 28th. The middle pair may be of shorter duration than the other two longer disturbances.

A total eclipse of the moon is visible on July 6 from 0533 to 0929 UT in the Americas and across to Australia. The moon will be full on eclipse day and will be at perigee on the 19th. Also a partial eclipse of the sun is visible from 1719 to 2009 UT on July 20 in extreme northern Asia, northwestern Europe, northwestern North America, Greenland, Iceland, and the Arctic regions. The sun will be obscured forty-six percent at maximum.

Ten and fifteen meters will provide good worldwide DX during the daylight and early evening hours on most days of the month. Expect conditions to peak during the late afternoon, with long- and short-skip signals.

Twenty meters will be open to some area of the world for the entire twenty-four hour period on most days of the month. The band should peak in all directions just after local sunrise, and again toward the east and south during late evening hours. During darkness, the band will peak toward the west, in an arc from southwest through northwest, that will take in Pacific areas.

Forty meters can often provide good DX from sunset through darkness till just after sunrise, despite the atmospheric noise levels — provided you choose times when local thunderstorm-related static is at a minimum.

Eighty meters can sometimes provide openings to DX areas during darkness and at sunrise, but signals will be weak and static will be strong. For these DX conditions, coastal stations often have a better chance of working DX than do stations in the center of large land masses.

ham radio

WESTERN USA

GMT	PDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
0000	5:00	—	20	—	15	15	10	10	20
0100	6:00	—	20	—	15	20	10	10	20
0200	7:00	—	20	—	15	20	10	10	20
0300	8:00	15	20	—	15	20	10	10	15
0400	9:00	15	20	—	15	20	10	10	15
0500	10:00	15	20	20	15	20	15*	15	15
0600	11:00	—	20	20	20	20	15	15	20
0700	12:00	—	20	20	20	20	15	15	20
0800	1:00	20	40	20	20	20	15	20	20
0900	2:00	20	40	—	20	20	15	20	20
1000	3:00	20	40	—	20	40	15	20	20
1100	4:00	20	40	—	20	40	20	20	20
1200	5:00	20	—	—	—	40	20	20	20
1300	6:00	20	20	20	—	40	20	20	20
1400	7:00	20	20	20	—	—	20	20	—
1500	8:00	20	20	20	—	—	40	20	—
1600	9:00	20	20	15	—	—	40	20	—
1700	10:00	15	20	15	—	—	—	20	—
1800	11:00	15	20	15	15	—	—	40	—
1900	12:00	15	—	15	10	—	15	40	15
2000	1:00	15	—	15	10	15	15	—	15
2100	2:00	—	15	—	15*	15	10	—	15
2200	3:00	—	15	—	15*	15	10	10	15
2300	4:00	—	15	—	15	15	10	10	20

JULY

MID USA

GMT	MDT	CDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
0000	6:00	7:00	—	20	—	15	15	10	15	—
0100	7:00	8:00	15	20	—	15	15	15*	15	15
0200	8:00	9:00	15	20	—	15	20	15	15	15
0300	9:00	10:00	15	20	—	15	20	15	15	15
0400	10:00	11:00	20	20	40	15	40	15	15	20
0500	11:00	12:00	20	20	40	15	40	15	15	20
0600	12:00	1:00	20	20	20	20	40	15	20*	20
0700	1:00	2:00	20	—	20	20	40	15	20	20
0800	2:00	3:00	20	—	20	40*	20	15	20	20
0900	3:00	4:00	—	—	40	40	20	20	20	20
1000	4:00	5:00	—	—	—	40	20	20	20	40
1100	5:00	6:00	—	20	—	40	20	20	20	40
1200	6:00	7:00	—	20	—	40	—	20	20	40
1300	7:00	8:00	20	20	—	20	—	20	20	20
1400	8:00	9:00	20	—	20	20	—	40	20	20
1500	9:00	10:00	20	—	15	15	—	40	20	20
1600	10:00	11:00	20	—	15	15	—	40	40	20
1700	11:00	12:00	20	—	15	15	—	—	40	20
1800	12:00	1:00	20	—	15	15	—	—	—	20
1900	1:00	2:00	20	—	15	10	—	—	—	—
2000	2:00	3:00	15	15	20	10	—	—	—	—
2100	3:00	4:00	20*	15	20	10	15	15	15*	20
2200	4:00	5:00	—	15	—	10	15	10	10	15
2300	5:00	6:00	—	20	—	15	15	10	15	15

EASTERN USA

GMT	EDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (CARIBBEAN S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
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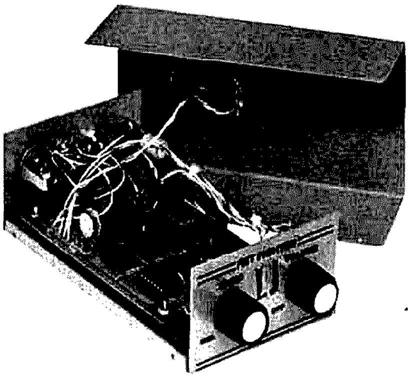
0100	9:00	15	20	—	15	20	15	15	20*
0200	10:00	15	20	40	15	20	15	15	20
0300	11:00	20	40	40	15	20	15	15	20
0400	12:00	20	40	40	20*	20	15	15	20
0500	1:00	20	40	40	20	40	20	20	20
0600	2:00	20	20	40	20	40	20	20	—
0700	3:00	20	20	—	20	40	20	20	—
0800	4:00	—	40	—	20	20	20	20	—
0900	5:00	—	40	—	20	20	20	20	—
1000	6:00	—	40	20	20	20	20	20	—
1100	7:00	—	20	20	20	—	20	20	—
1200	8:00	20	20	20	20	—	20	20	20
1300	9:00	20	20	15	20	—	20	20	20
1400	10:00	20	15	15	15	—	—	20	20
1500	11:00	20	15	15	15	—	—	20	20
1600	12:00	—	15	15	15	—	—	—	20
1700	1:00	—	15	15	10	—	—	—	—
1800	2:00	—	15	15	10	—	—	—	—
1900	3:00	15	15	15	10	20	15	—	—
2000	4:00	15	15	20	10	20	15	—	20
2100	5:00	20*	15	20	15	20	15	15	15
2200	6:00	20	15	20	15	20	15	15	15
2300	7:00	15	20	20	15	20	15	15	15

NEW products

fist fighter keyer

Designed exclusively for straight-key users, the fist fighter is an electronic keyer that accurately times the length of dots, dashes, and the



spaces between them. The fist fighter uses a standard 1:3:1 timing ratio so that code sounds clean and crisp. No new hand motions are required, and an automatic tune-up feature is built in so that normal key-down tune-up is possible without the need for extra switches. Speed is variable from about three to over thirty WPM, and a built-in sidetone oscillator with variable tone is provided. The fist fighter uses CMOS digital circuits and it will key grid-block and solid-state transmitters/transceivers. It can be used as a code-practice oscillator and for teaching how to send code properly.

The fist fighter is available in two forms: kit ($59.95 plus $2.50 shipping and handling) and assembled/tested ($79.95 plus $2.50 S/H), each with a limited ninety-day warranty. Additional information and specifications are available from the Blacksburg Group, Box 242, Blacksburg, Virginia 24060; telephone 703-951-9030.

no-radial vertical

Cushcraft has introduced R3, the no-radial 10, 15, and 20-meter gain vertical antenna. R3 is perfect for limited-space applications like condominiums, apartments, mobile homes, and small urban lots. It is a half-wavelength, end-fed 22-foot radiator with remote tuning for broadband coverage. Installation is very simple with only one square foot of space needed. It can also be telescoped for easy carrying and storage.

Because of its unique design, R3 does not need tower, rotator, large support mast, or tuner. It is a complete antenna system for hams who are concerned about neat appearance and maximum performance.

R3 antennas are available through all major Amateur Radio dealers worldwide. For more information, see your local dealer or contact Cushcraft Corporation, P.O. Box 4680, Manchester, New Hampshire 03108; telephone 603-627-7877.

computer logging system

Compu-Log is a fully computerized logging system for the Amateur Radio operator looking for the competitive edge. Compu-Log provides a printed, scored and duped log complete with dupe sheet. Confirmation of contacts can be printed on address labels in alphabetical order by callsign for attaching to your QSL cards. In addition, many valuable contest and operator statistics can be printed. These include number of contacts each hour on each band and total contacts for each country on each band. For multi-operation stations, Compu-Log gives you a breakdown of the total operating time, indicating number of contacts, duplicates, and contact rate for each operator on each band, and cumulative totals.

Compu-Log is written for the TRS-80 Model I computer with 48k memory, at least one disk drive, and the Epson MX-80 printer. Modified versions for other printers and the TRS-80 Model III can be created.

Versions of Compu-Log for the CQ World Wide DX Contest and ARRL DC Contest are available now. Other versions for the CQ WPX and IARU Radiosport contests will follow shortly. While Compu-Log is written for use by U.S. stations, modified versions for non-U.S. stations can be created.

For more information, contact Contest Software, Peter Chamalian, W1RM, Savarese Lane, Burlington, Connecticut 06013.

IC-290A 2-meter mobile

ICOM announces the IC-290A 2-meter mobile VHF transceiver, priced at $549.00 including the HM8 Touchtone mike.

The IC-290A includes the following features: five memories plus two VFOs; priority channel; programmable offsets; 5 kHz or 1 kHz tuning; full-scanning capability; and fm USB/LSB/CW capabilities. The compact size of the IC-290A is another excellent feature: 6-11/16 × 2-1/2 × 8-5/8 inches.

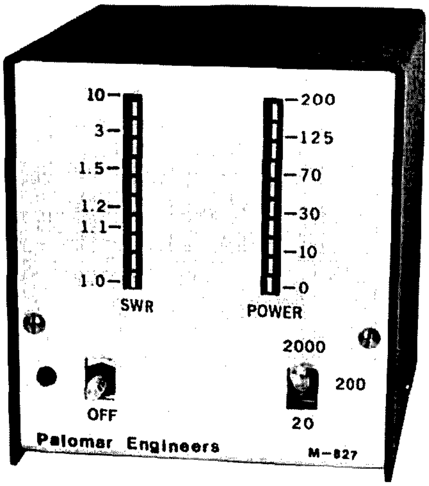
For more information, write ICOM, Suite 307, 3331 Towerwood, Dallas, Texas 75234.

automatic SWR meter

Palomar Engineers introduces the new M-827 SWR meter. This new meter computes SWR automatically and displays it on a light bar. The "sensitivity" knob has been elimi-

NEW products

nated. SWR reading is always correct regardless of power level, and the light bar follows changes instantly. A second light bar displays power. Unlike the analog panel meter it replaces, this meter follows with the speed of light so you can see all the SSB peaks.



The frequency range of the M-827 SWR meter is 1-30 MHz. Power ranges are 20, 200, and 2000 watts. The SWR scale is 1 to 10 with a logarithmic response that gives much improved resolution where you need it. The M-827 is a compact 4 × 4 × 5 inches with a brushed aluminum control panel, baton switches, and a black vinyl cover. The light bars are 2 inches long with a bright red display.

The M-827 SWR meter sells for $97.50. For further information write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025; telephone 714-747-3343.

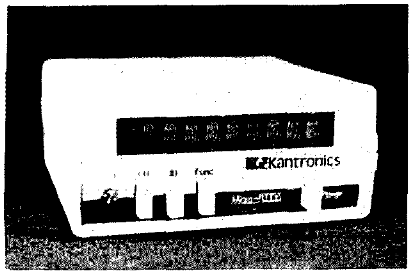
Micro-RTTY

Kantronics is introducing the latest development in RTTY send/receive devices with the Micro-RTTY.

NEW products

The Micro-RTTY converts CW from any keyer or keyboard into standard AFSK two-tone RTTY or two-tone CW ID. Micro-RTTY sends and receives RTTY at 60, 67, 75, and 100 WPM, plus ASCII 110 baud.

Special CW characters allow for entering Morse ID mode or sending a carriage return/line feed character without ever touching the unit. A printer attachment is also provided via a back panel connection.



The Micro-RTTY receives any shift of RTTY and displays the message on a ten-character, 3/8-inch high, vacuum-tube fluorescent display.

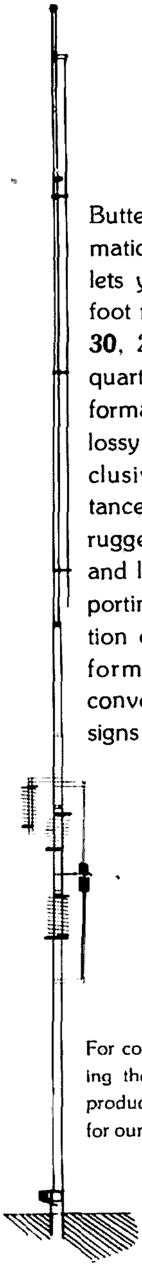
The package is small, just 2-1/2 by 5-1/2 inches and the 9-Vdc power supply is included.

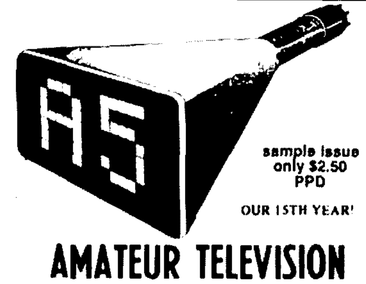
For more information, contact Kantronics, 1202 E. 23rd Street, Lawrence, Kansas 66044.

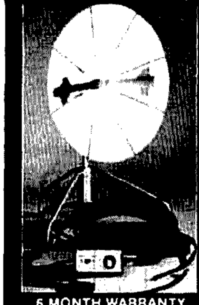
Clutterfree modular consoles

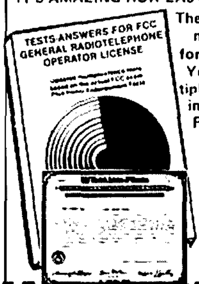
Clutterfree modular consoles are made of industrial particleboard finished with Plyocite (polyester) overlays of pecan woodgrain. They are available in two models, single deck or double deck.

These modular consoles consist of seven to ten pieces and are shipped unassembled. Instructions and diagram are enclosed with each unit, (no



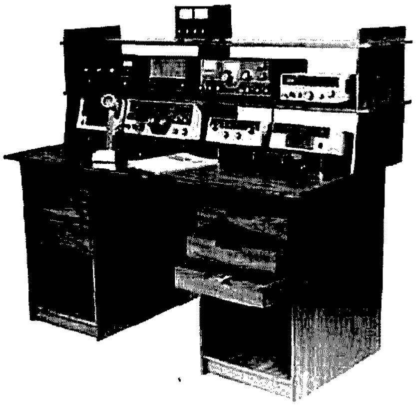






NEW products

special tools, glue, or nails are necessary). Assembly time is approximately twenty minutes. Dimensions: height single deck 42 inches; the equipment shelf is 14-1/4 inches front to back with a 9-7/8 inch clearance height; height double deck 50 inches, with clearance heights 8-1/2 inches between equipment shelves and desk top; console deck 16 inches deep at base, desk width 57 inches, depth 30



inches. Desk top is standard 29 inches from the floor, and the space between the pedestals is a generous 22 inches. The assembled weight is approximately 150 pounds, and the console top will support approximately 400 pounds with face plate.

The cost of the consoles is only $203.35 for the single deck, $312.70 for the double deck. The optional face plate can be purchased for an additional $15.10. Drawers are available for your console.

All orders will be processed within seven days. For more information, contact Clutterfree Modular Consoles, P.O. Box 5103, Tacoma, Washington 98405; telephone 206-759-1611.

AUGUST 1982 / $2.50

ham radio magazine

- radio wave propagation
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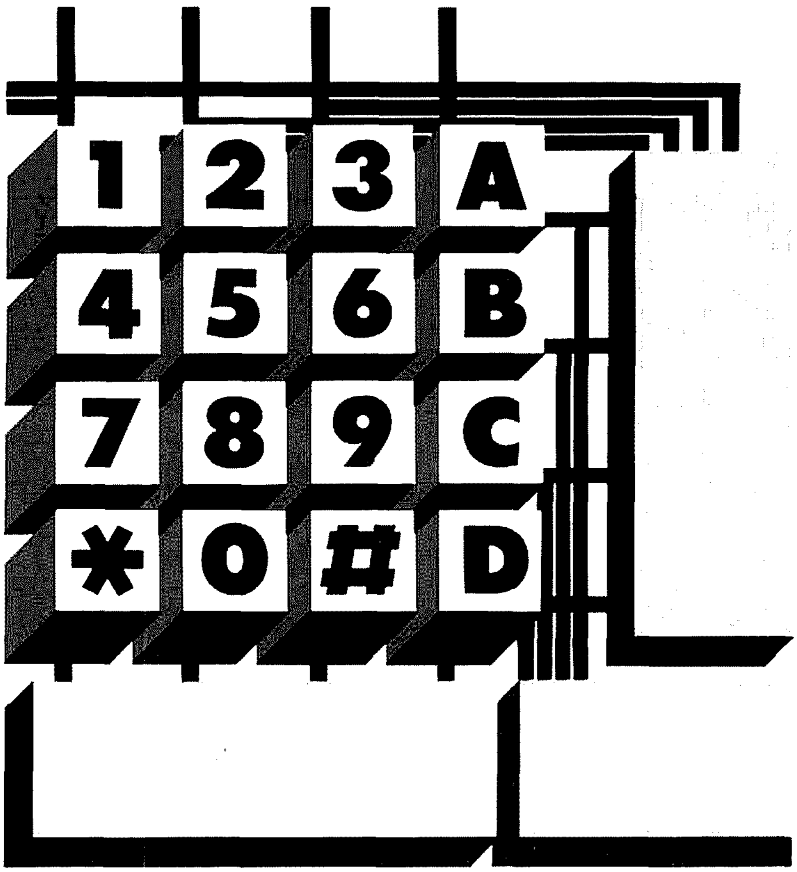
- microwave network for multimode communications
- Heath oscilloscope mods

a portable auto-dialer



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ham radio

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AUGUST 1982

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contents

Observation & Opinion

A basic knowledge of electronics and radio communications, moderate skill with Morse code, and a nodding acquaintance with the FCC's rules and regulations. That's all it used to take to get an Amateur license and put a station on the air. Not any more; today's Amateur had best add a couple years of law school to his basic preparation effort. The way things have been going in the courts and with local lawmakers, it's going to take that and more, if we're going to defend our right to get on and stay on the Amateur bands!

Amateur Radio has never been a stranger to legal problems. Zoning restrictions and antenna height ordinances, restrictive covenants, uncooperative landlords and even an occasional lawsuit over TVI have made life miserable for a small number of Amateurs at times. Today, however, the threat to our hobby and service is far more pervasive. Let's look at some recent happenings that could seriously hurt us all.

In California last year, the state legislators passed a law making it a crime to make or sell *any device or component that could be used in a device that could be used to unscramble pay-TV signals.* This spring the Chicago City Council proposed an ordinance that would *require the builder of any antenna structure to spend hundreds,* if not thousands, *of dollars on fees and paperwork before beginning construction* on his proposed antenna. In mid-June a federal judge in Minneapolis *issued an injunction preventing stores in that area from selling antennas that could be used to recieve Home Box Office movies* (transmitted in the 2-GHz band). The lawyer for the HBO distributor said they also planned to ask the court to force owners of such antennas (which could, of course, be used by Amateurs on the 2300-2450 MHz Amateur band) to sign over ownership of the antennas to HBO and pay HBO the $20 monthly fee charged to HBO subscribers. Finally, the city of Burbank, Illinois, passed an ordinance this spring that not only severely restricts the use of Amateur and CB antennas (and places a one-year moratorium on their construction) but also makes it a crime to cause any type of radio interference!

In the case of Burbank, a suburban Chicago community of about 40,000, the operation of *any* transmitter that interferes with *any* TV, "musical instrument, phonograph or other machine or device designed for the production or reproduction of sound" is now a criminal offense. The penalty is a fine of $25 to $1000 for each violation or each day the violation continues, and those violating the ordinance are also subject to arrest. The same sanctions apply to violators of the new antenna restrictions; though existing structures may (with some limitations) be grandfathered, any Burbank Amateur or CB operator who puts up an antenna during the next year may well find himself arrested and fined!

The Burbank ordinance is perhaps the most direct challenge to Amateur Radio operators that has been made in many years, and reaction from the Amateurs of Burbank and surrounding communities has been swift and strong. Under the leadership of Burbank DXer WA9EKA, Burbank Amateurs have pledged over $2,000 toward mounting a court challenge to the ordinance, and retained the services of W9WU, a Chicago attorney who's been very active in a number of Chicago area antenna controversies. The Wheaton Community Radio Amateurs, sponsors of the annual Wheaton Hamfest, have contributed $500 to the battle, and a number of other area groups and individuals are also supporting the fight. The ARRL has been asked for its support and participation in what is shaping up as a lawsuit that could be a crucial landmark confrontation between the rights of individual Amateurs and repressive local regulations. Despite several meetings on the subject and the enthusiastic support of a number of Directors, the League still seems uncertain as to just what role it should play.

A well-mounted court fight is expensive. It's estimated that this one will run at least $10,000, and costs could reach $20,000 before it's settled. This is our fight, not just their fight — to challenge this law in court and lose because of inadequate financial support would establish a precedent that would be a nationwide disaster for Amateur Radio. If Burbank prevails, this ordinance could be the model for similar restrictions across the country!

On a happier note, a little forewarning and preparation can often forestall an expensive Burbank-type confrontation. In the case of the Chicago antenna ordinance, a few words to key aldermen by W9WU and other concerned Amateurs while the ordinance was still being drafted resulted in language that requires only a building permit for towers used by stations licensed under Part 97 of the FCC rules. The first Amateur Radio installation under Chicago's new regulations was a 70-foot Hy-Gain crank-up, installed June 7 by WA9IVU with the City of Chicago's full approval.

Remember, Burbank's fight is your fight. Send your contribution to the Burbank Tower Fund, Roger Borowski, WA9EKA, Chairman, 6107 West 80th Place, Burbank, Illinois 60459.

Joe Schroeder, W9JUV
associate editor

comments

not for beginners

Dear HR:

I have just ordered a Datong FL-2 because of the fine paper by Dr. Tong in the November, 1981, issue of *ham radio*. I would like to encourage this type of presentation by designers of commercially available Amateur equipment.

I am much less pleased with the papers by Jan K. Moller, K6FM, ["Understanding Performance of HF Receivers," November, 1981, p. 30]. The title implies that the author is trying to explain something to the reader who is not technically sophisticated. I feel he did not present the material on IMD at a low enough level. I have read his paper several times but still do not understand IMD intercept, etc.

I'm aware that many of the papers in your journal are not addressed to beginners, but titles that start off with "Understanding . . ." should impart that understanding.

I guess I am frustrated because I read the paper eagerly, expecting to fill a recognized void in my knowledge, and I was not able to do so.

Joseph A. Worrall, M.D., KL7HT
Fairbanks, Alaska

In the article about receiver performance data, the plan was to provide a brief explanation of the common technical terms found in an HF receiver's data sheet. I also wanted to show how this data can be interpreted in appraising the capabilities of the various sets on the market. The very complex combination of rf preamplifier performance and first stage characteristics — which together determine the receiver's behavior with regard to unwanted signals — was outside the scope of the article.

A majority of hams live in or near population centers, with their accumulation of commercial transmitters (mobile as well as fixed), broadcast, TV, police, paging, truck dispatch, and so forth. The possibility of stations outside the Amateur service generating harmonics or beatnotes that fall in an Amateur band is great. Fairbanks is probably better than most cities, but try to tune across the 80-meter band and see if you cannot find a few strange signals that are caused by non-ham signals beating against each other. This is what has generated the interest in the term "inter-modulation distortion," or IMD for short. Naturally, two ham signals off the frequency to which you are tuned can cause the same beatnote if their frequency relationship is right (see the article for the formula). I am not entirely happy with the word distortion *in this connection; to* distort, *to me, means to change unfavorably — but that happens to be the official term.*

The reason we exemplify the third-order IMD is that this one is the most troublesome in actual receivers. Higher harmonics resulting in frequencies nearby the desired one are usually very much smaller in amplitude, partly because the front-end (rf stage) selectivity of the receiver keeps them down.

The whole problem lies in the fact that there is no such thing as a perfect first mixer. The diode bridges used today are much better than the old tube mixers which, in the early days, commonly had two stages of tuned rf in front of them for protection. The trouble is nonlinearity, of course, which will cause the mixing of any incoming signals. The data in the article, which incidentally is based upon the Kenwood TS-830S, points up the quality of this set by the fact that the off-frequency signals will have to be about 50 dB over S9 each *to generate an audible beatnote on the frequency to which you are listening (tuned).*

The intercept point expression is harder to fathom, to be sure, and is strictly a theoretical definition. I mentioned it simply because it is beginning to appear in reviews of new equipment. The idea is that the slower the ratio of build-up of intermod beatnotes for increasing rf input levels, the higher the intercept point value in dBm. Once the point has been established, you can calculate the receiver's behavior for the signal levels that are typical for on-the-air operation.

I hope the above comments have been of help to you in understanding my article.

Jan K. Moller, K6FM
Simi Valley, California

2-meters outlawed?

Dear HR:

Two-meter Amateur Radio outlawed? The essay on page 10 of the March, 1982, issue is ominous enough, but it just touches the tip of the issues raised by the question of interference by Amateur stations to cable television systems.

One notable fact is that while virtually any Amateur station in the 2-meter band can cause interference, only *one* CATV channel is affected (Midband Channel E). This one channel covers the entire 2-meter band (144-149.7 MHz). It would indeed be unfortunate if the entire 2-meter community were forced to vacate in order to preserve a single CATV channel.

Another point is even more ominous: the problem is not confined to the 2-meter band. Cable channels K and XX fall in the Amateur 220 and 440-MHz bands. If a precedent is established resolving 2-meter interference to CATV, is it not just a matter of

(Continued on page 63)

presstop de W9JUV

THE HOUSE VERSION OF K7UGA'S COMMUNICATIONS ACT REWRITE, HR.5008, unanimously passed the House Committee on Energy and Commerce June 3 without any restrictions on commercial involvement in Amateur exam preparation. The provisions permitting the FCC to regulate RFI susceptibility also remained intact, despite vehement opposition from the Electronic Industries Association. Though the bill is already extremely favorable to Amateur Radio with its provisions for Amateur participation in monitoring and exams, it's also hoped that additional benefits can be obtained by having language strengthening the case for federal preemption added to the accompanying committee report.

In Late June HR.5008 Had Still Not reached the House floor, but when it does quick passage seems certain. After that the differences between the House version and S.929 still must be reconciled, but it may reach the President for signature by the end of July.

A Pennsylvania Preemption Bill, which would remove most Amateur antennas in that state from local control, has been stalled in committee since early June. Pennsylvania Amateurs are urged to check with their representatives to help get it moving again.

A NO-CODE AMATEUR LICENSE STILL LOOMS large at the FCC, with the topic scheduled for discussion at the Commission's July 1 agenda meeting. Personal Radio Bureau Chief Jim McKinney touched on the subject at the annual AFCEA Convention Amateur Radio luncheon in Washington mid-June, pointing out to the 180 or so attending that a no-code license may well be what's needed to attract today's computer-oriented youngsters to Amateur Radio.

Four Alternatives Are Considered Likely in any Commission proposal on no-code. One, an entry level "Communicator" license, was previously rejected by Amateurs when restructuring, Docket 20282, was under consideration. Another, a very high-level "Experimenter" class license, has not proven popular in Canada where it was introduced to encourage the development of packet radio. A third alternative that's likely to be received favorably by the Commission, since it would have little impact on the FCC's limited resources, would be to simply eliminate the code requirement for the Technician license and let it become the no-code license. The fourth alternative would be to reject no-code entirely.

It's Certain That No-Code Is Going to be proposed to the Amateur community again, if not already by the time this sees print almost certainly by the end of 1982.

6 AND 10-METER REPEATER ERP LEVELS have now been changed to agree with those on 2 meters, by an FCC Report and Order on PR Docket 81-697 released June 22. The new effective radio power limits vary from 100 watts for antennas over 1000 feet above average terrain to 800 watts for those under 50 feet, and became effective June 29.

PROPOSED PHONE BAND EXPANSION ON 20 METERS and the other HF Amateur bands is still open for comments with the due date now extended to August 16. In addition to proposing opening 20 meter phone down to 14150 and shuffling operator class privileges on that band, the FCC is also soliciting comments as to possible changes in the other HF phone bands. The editorial in May QST has a discussion of some of the issues involved.

An Original And Five Copies of Comments on PR Docket 82-83 must be at the Commission by August 16. Reply Comments are due September 16.

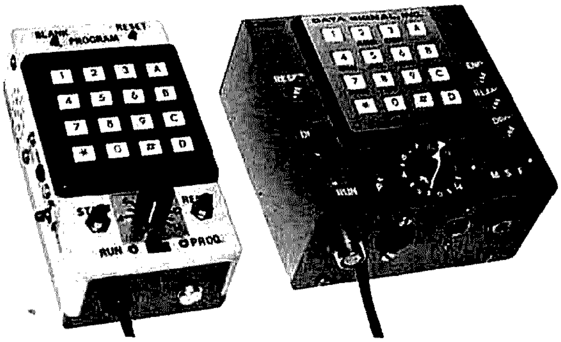
20 kHz 2-METER CHANNEL SPACING has now been adopted by Amateurs in Wyoming and Utah, bringing them into agreement with the Pacific Northwest and western Canada. Arizona and Nevada are also reported to be considering a similar change, which would leave California the only state west of the Rockies to retain 30/15-kHz spacing on 2 meters.

ARRL VHF CONTEST RULES WILL probably remain the same for September as they were in June, despite some discusssion that grid squares would replace sections for the next run. An ad hoc committee has been working on the change, but will probably not be finished in time to implement any alterations before the September fray.

220 MHz CW/SSB Enthusiasm is growing rapidly, if June contest activity was any indication. W1FC on Pack Monadnock boosted their best previous 220 multiplier by 11 to 28 sections, three on E-M-E, and W2FZ logged 24 sections compared to a previous high of 22. Some of the increase was due to an excellent aurora opening, of course, and some to rules changes permitting single band entries.

THE FORMER WB6JAC HAS BEEN CONVICTED by a U.S. District judge on two of three felony counts of broadcasting obscene, indecent and profane language plus four counts of operating a transmitter without a license. His license had been revoked by the FCC a year ago for jamming activities; his subsequent operation resulted in his arrest April 30 by U.S. marshals and FCC officials. Sentencing was set for the end of June, with a prison term and heavy fine considered likely.

THREE INTERNATIONALLY KNOWN AMATEURS BECAME SILENT KEYS in June: W2PV, W3KT, and HS1WR. Jim Lawson, W2PV, was an antenna expert whose fine ham radio articles made him as well known as did his outstanding contest station's signal. Atlantic Division ARRL Director Jesse Bieberman, W3KT, served Amateur Radio as both an ARRL director and Third District QSL manager, and was himself a top DXer. Gen. Kamchai Chotikul, HS1WR, was one of Thailand's most active Amateurs and, as president of the Radio Society of Thailand, one of the strongest pro-Amateur Radio voices in both his own country and all of Southeast Asia.



Of two versions of the auto-dialer built by the author, the one on the left was housed in a plastic case and the other in a standard LMB metal box. Both units are used in the author's cars, but only the one on the right has provisions for using the car battery as a supply. The additional connectors are for using the auto-dialer with other rigs.

a portable Touchtone™ auto-dialer

Compact design using standard CMOS devices is featured in this accessory for mobile operation

Repeater autopatch facilities are an exciting and important aspect of Amateur Radio. But for the mobile operator, dialing while driving, particularly at night, is both dangerous and inconvenient. Commercial dialers for Amateur use do exist, but they haven't become very popular. Perhaps they are too difficult to use or program, have high current demands for memory retention, or lack versatility.

The do-it-yourself autopatch dialer described here doesn't have these problems. It's portable and compact, uses standard CMOS parts, and has very low battery drain. It's a snap to program, and doubles as a full-feature manual encoder as well.

description

Using CMOS memory, the dialer can store sixteen, sixteen-digit telephone numbers. Its keypad incorporates all sixteen Touchtone™* digits. Battery drain in standby, including memory retention, is 2 microamps. A standard 9-volt transistor battery can power the unit from nine months to a year, depending on

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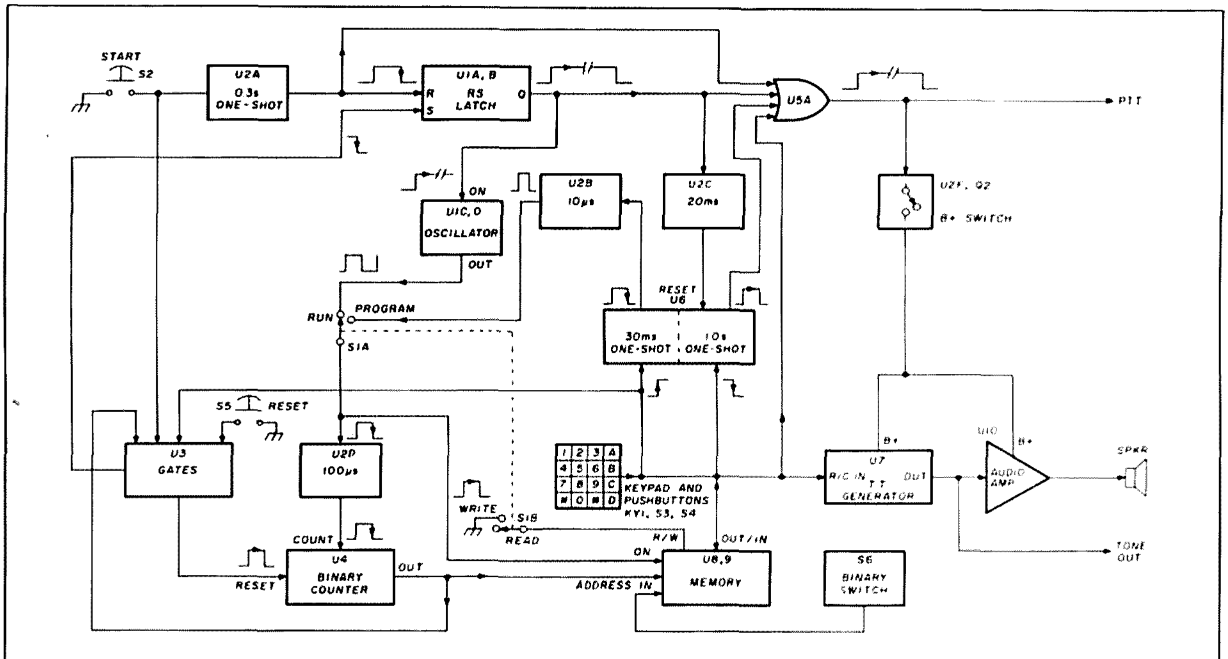


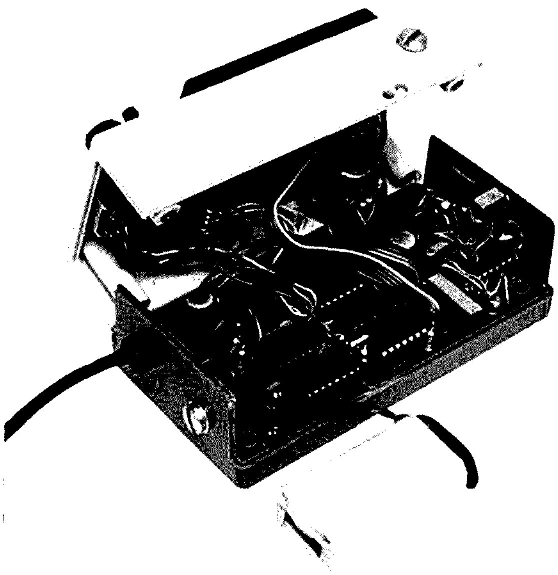
fig. 1. Block diagram of the portable auto-dialer. Circuit features CMOS memory which can store sixteen 16-digit telephone numbers and provides three switch-selected dialing speeds.

use. Three switch-selected dialing speeds are provided: 55 milliseconds per digit for state-of-the-art patches, 250 milliseconds per digit for slower patches, and 1 second per digit for those machines that use tone-to-rotary-pulse converters. To ensure full capture of the repeater, dialing tones are output 300 milliseconds after the dialer keys the transmitter PTT line.

Programming is easy: the desired telephone number is simply dialed in. Pauses can be inserted, and with a simple addition to the circuit, a carrier-drop can be programmed in the middle of a dialing sequence for those patches that require it. The dialer can also be used manually as a full function Touchtone™ pad, including automatic PTT and a 1-second hang-on time after each digit. A side-tone amplifier and speaker are included for monitoring the tones.

circuit

The heart of the circuit is the Harris Semiconductor HM3-6562-9 CMOS memory. (Refer to the block diagram and schematic, **figs. 1** and **2**). This 1k RAM is configured as 256 x 4 and comes in a compact sixteen-pin package. Its common input/output lines are another asset. The chip comes in several versions. The -9, industrial version, is used here instead of the slightly cheaper -5, commercial version, for two reasons. First, standby current drain is an order



The auto-dialer in this plastic case uses an earlier version PC board that is a hair narrower than the board shown in *fig. 3*. The battery fits right on top of the ICs. Note the 1-inch speaker in the upper right corner of the cover.

*Touchtone is a registered trademark of the American Telephone and Telegraph Company.

of magnitude less for the -9, typically 1 microamp per chip. Second, although the chip is specified for a maximum allowable voltage of 8.0 volts, the -9 version is tested by the manufacturer to withstand 10.0 volts. That lets us use a standard 9-volt transistor battery to power the unit.

Two memory chips, U8 and U9, are used — one for the column and one for the row inputs of the Mostek Touchtone™ generator chip, U7. U7 has built-in pull-down resistors on both row and column inputs and can be directly interfaced to U8 and U9. This simplifies the dialer's design. U10 is a popular audio amp designed for battery operation. With a miniature speaker, it provides audible feedback of tone output. R19 acts as a volume control, and C13/R23 form a parasitic suppressor during negative voltage swings. Both U7 and U10 are switched on by Q2 only during dialing or manual operation to keep standby current drain to a minimum.

programming

To program, U8 and U9 are switched to the write mode with run/program switch S1. U5b senses keyboard and pushbutton closures and triggers a 30-millisecond delay pulse formed by one half of U6. That delay covers contact bounce of the keyboard or pushbuttons. The falling edge of that pulse triggers a 10-microsecond write pulse, formed by R3, C16, and U2b, and is applied to the chip-enable (CE) lines of U8 and U9. (Holding the read/write, R/W, line low and pulsing the CE line has the same effect as the more familiar sequence of holding the CE line low

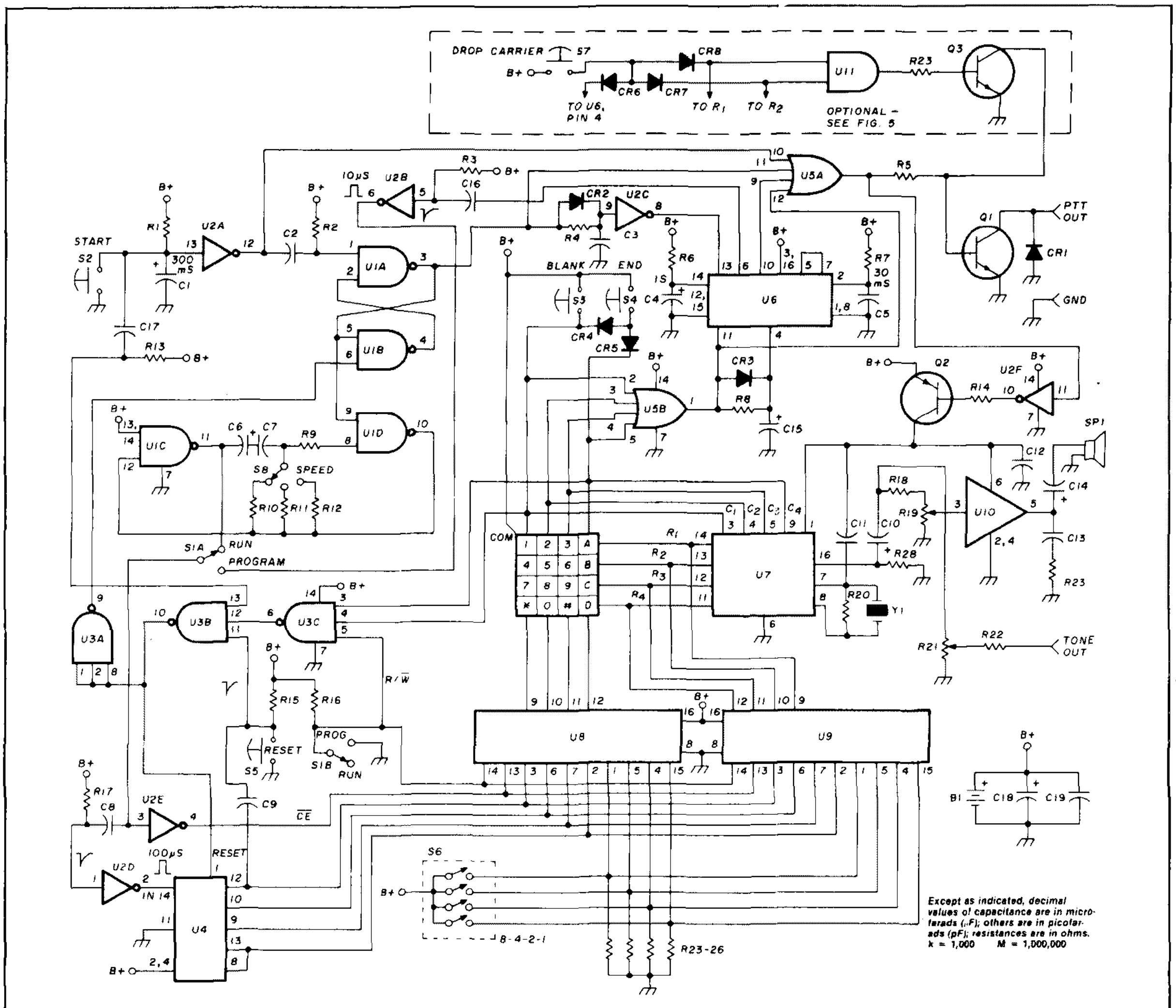


fig. 2. Auto-dialer schematic diagram. The design is simplified by taking advantage of direct interface capability between U7, the Mostek Touchtone™ generator chip, and the two memory chips, U8 and U9.

and pulsing the R/W line.) In turn, the falling edge of the write pulse is delayed an additional 100 microseconds by R17, C8, and U2d, and is used to increment binary counter U4 at the end of the write cycle.

During the write cycle, the respective key or button closure enters a logical one into the appropriate memory locations, and a logical zero elsewhere. A network consisting of CR3, R8, and C15 prevents any contact bounce caused by releasing a key or pushbutton from retriggering another write cycle. As U4 is incremented, its four output lines address each succeeding location in memory, for a total of sixteen digits. The other four memory address lines are selected by binary-coded switch S6, which determines which of sixteen possible telephone numbers is being programmed or dialed.

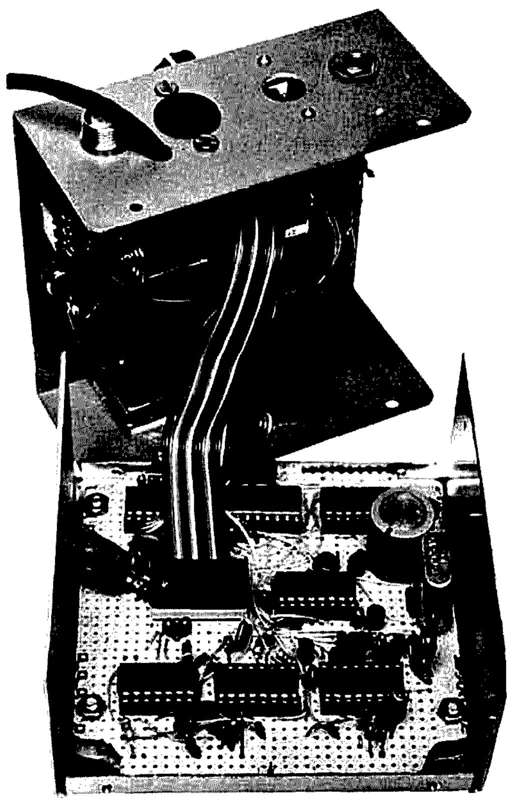
U7 does not produce any tones if only column inputs are actuated. The dialer uses that feature to produce a blank, for pauses, and an end-of-sequence code to stop dialing at the end of a number. The blank is programmed by S3, which is simply a column-1 input. END is programmed by S4, which keys both columns 1 and 4. (Two column inputs are necessary to distinguish END from normal key closures.)

dialing

The automatic dialing sequence is started by pushbutton switch S2. R1, C1, and U2a add a 300-millisecond delay before setting an RS latch formed by U1a and b, which starts the dialing. However, the PTT line is brought up as soon as S2 is depressed, and U7 and U10 are turned on through Q2. The RS latch holds Q1 and Q2 on after the delay has passed, and starts the square wave oscillator, formed by U1c and d. The first half of each cycle turns on U8 and U9, whose outputs *actuate* the appropriate row and column inputs of U7. The second half of the square wave provides the inter-digit time and increments counter U4 for the next digit. This sequence continues for sixteen digits or until an END is encountered. At an END, U3 resets the RS latch and U4, and stops the oscillator.

When the oscillator stops, however, it increments counter U4 one more count. To restore the counter to zero (say, for programming) or to abort a dialing sequence, S5 is provided as a reset key. Start switch S2 is also wired to reset U4 and the RS latch, and that eliminates the need to manually reset before dialing.

For manual dialing, you need only depress the keyboard keys. Releasing each key triggers a 1-second PTT hang-on timer using the remaining half of U6. A delay network consisting of CR2, R4, C3, and U2c prevents U6 from adding any hang-on time during an automatic dialing sequence.



This version of the auto-dialer was built using point-to-point wiring. A ribbon cable and connector connects the two halves of the case together to facilitate servicing. A 4½-volt backup battery can be seen in the cover.

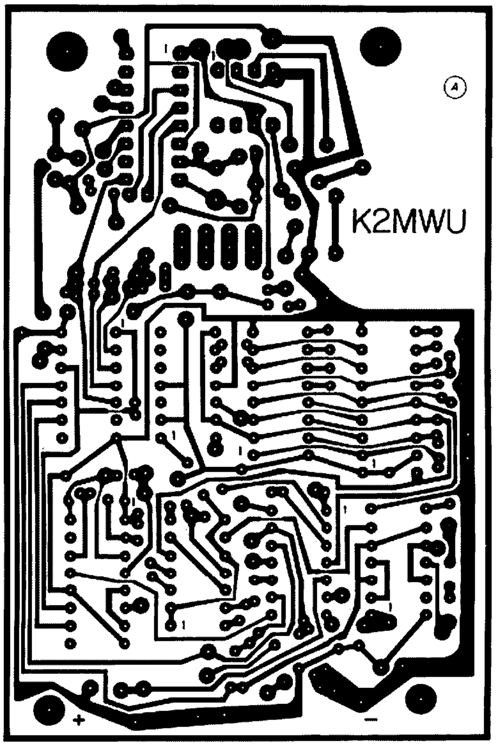
construction

Using the pattern shown (**fig. 3**) a PC board can be made, and the dialer built in a compact package. Several jumpers are shown on the component-placement diagram, a normal consequence of using a one-sided board with ten ICs. Parts layout is not critical, so point-to-point wiring can also be used. I've used both approaches with equal success. Sockets should be used for all ICs except U10, and normal precautions should be observed when handling CMOS chips. (I found U8 and U9 to be more susceptible to accidental damage than the other CMOS chips.) C12 should be mounted on the foil side, as well as most of the longer jumpers. Wire-wrap wire is particularly useful for jumpers — the insulation does not melt or recede during soldering. Note the land clusters for rows 1 to 4 and columns 1 to 4. These tie points are for connecting the key-

board and pushbuttons, as well as the column and row jumpers to U8 and U9 respectively.

Generally, parts values are not overly critical. Forgiving Schmitt-triggered buffers are used for pulse shaping, and RC combinations have been chosen to accommodate variations in parts values. The only components that will need adjustment and selection are R6, R10-R12, and R22. R22 affects the tone output level to your rig. A large value will lower the tone level but will not load your rig's tone input port. Typical values will be 10k to 100k; 10k will ensure adequate levels for most any rig.

R10 to R12 determine the dialing speeds, and dialing speed is directly proportional to these resistances. But for any given value, the dialing speed can vary over a 25 percent range because of chip-to-chip variations. Ballpark values for the speeds given earlier are 91k, 390k, and 820k. You can adjust these values by trial and error or by using an oscilloscope. When making these adjustments, note that the first cycle of the square wave oscillator will be longer than the rest, a characteristic of this type of oscillator. Similarly, the PTT hang-on time is directly proportional to R6; 330k provided 1 second in my unit.



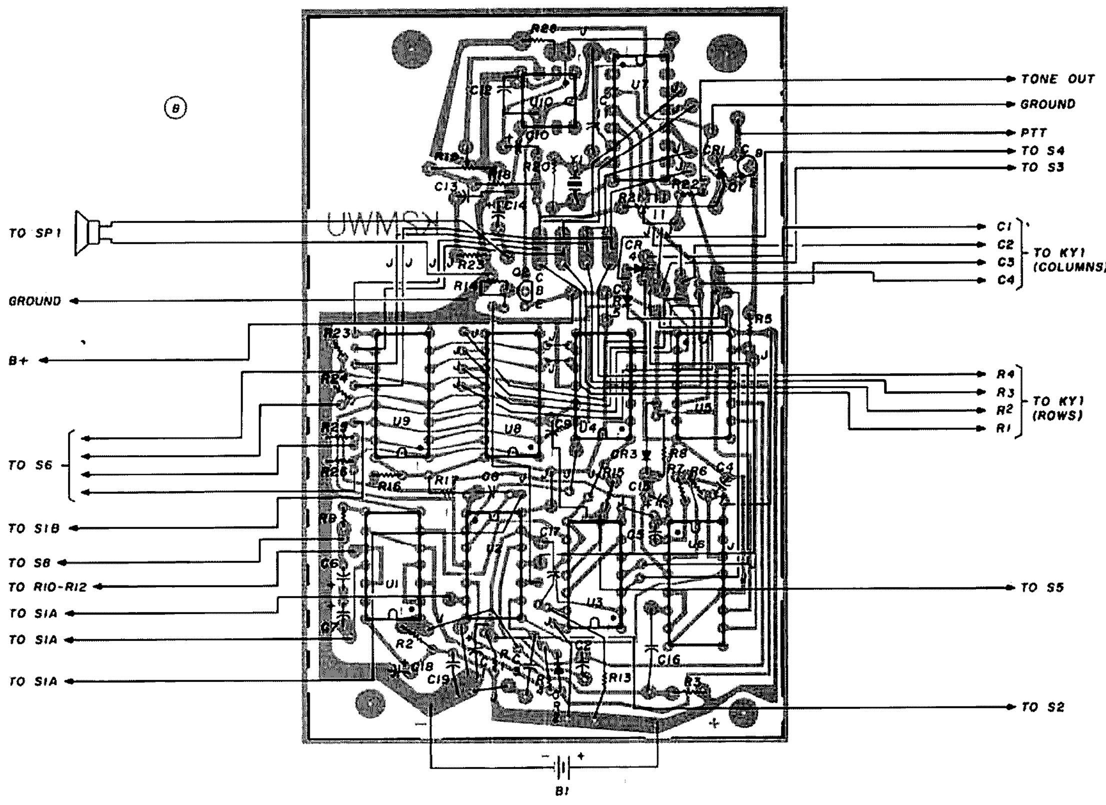


fig. 3. Foil side of the auto-dialer PC board, *A*, and component placement, *B*.

Dipped tantalum capacitors are used throughout the circuit because of their small size. To save space, a 1-1/2 or 1 inch speaker should be used for the side-tone monitor. The monitor needn't be loud to serve its purpose. Miniature pushbutton and slide switches also make for a compact unit. Instead of using a single-pole, three-position selector switch for S8, **fig. 4** shows how to use a double-pole three-position slide switch instead. Binary switch S6 may be harder to find in miniature form. I used an Eeco Series 21 Stripswitch and fitted it with a short shaft, but a thumb-operated Cherry T-50 series switch is almost as small and will work just as well.

Some autopatch facilities require that you drop your carrier between accessing the patch and dialing a number. A carrier-drop feature can be added with the circuit shown in **fig. 5**. The function is implemented by using two row inputs simultaneously, which, like two column inputs, does not produce any tones from U7. A two-input AND gate for U11 can be obtained directly or with a combination of gates. S7 is used to program the carrier drop. Note that this circuit is not provided for on the PC board.

A standard 9-volt transistor battery will power the dialer, including memory backup, for a long time, especially if alkaline batteries are used. An on/off switch is not necessary since standby battery drain, for other than the memory, is practically zero. (Battery drain increases to about 60-80 milliamps for the few seconds when tones are generated.) Replacing the battery is no problem. Because U8 and U9 will retain their contents down to 2.0 volts and use so little current, C18 can power the memory for ten or more minutes while changing batteries.

For those who desire to power the unit by a car or base station supply, **fig. 6** shows a suitable circuit that includes a backup battery for portable use. The backup battery should be at least 4.5 volts, to adequately power U7, and no more than 7.0 volts, to ensure automatic switch-over when the external supply is connected.

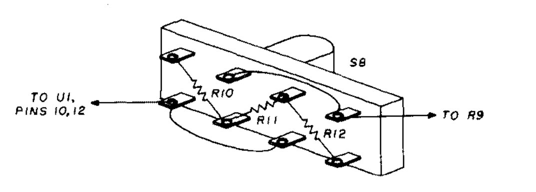


fig. 4. A three-position speed-selector switch for S8 can be made from a miniature double-pole, three-position slide switch. The switch terminals also provide tie points for R10, R11, and R12.

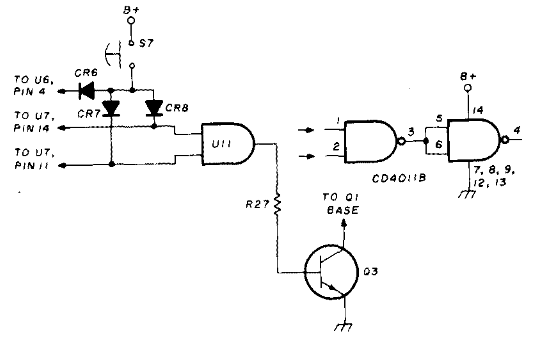


fig. 5. This optional circuit allows you to program a carrier drop for the length of one digit. U11 is a standard CMOS AND gate, such as a CD4081B. The AND function can also be implemented with standard NAND gates, as shown. Q3 turns off Q1, momentarily cancelling the PTT function.

B1	standard 9-volt transistor battery
C1	0.33 μF tantalum
C2	330 pF disc
C3,C5	0.02 μF disc
C4	3.3 μF tantalum
C6,C7	1.0 μF tantalum
C8,C9, C16,C17	100 pF disc
C10	2.2 μF tantalum
C11	10 pF disc
C12,C19	0.1 μF disc
C13	0.05 μF disc
C14,C18	100 μF electrolytic
C15	0.1 μF tantalum
CR1	1N4002 or equivalent
CR2-CR8	1N914 or equivalent
KY1	2-of-8 Touchtone™ keypad, with common
Q1	2N2222A
Q2	MPS3702
Q3	MPS3704
R1,R4	680k
R2,R16,R17, R23-R26	1M
R3,R13,R15	100k
R5,R14	3.3k
R6,R8	330k
R7	2.2M
R9,R20	10M
R10-R12	91k, 390k, 820k, respectively (see text)
R18	39k
R19	10k trimmer pot
R21	10k ten-turn pot
R23	10 ohms
R27	2.2k
R28	1k
S1	DPDT miniature slide switch
S2-S5,S7	miniature momentary pushbutton switches
S6	sixteen-position binary coded switch (8-4-2-1)
S8	one-pole, three-position switch (can use two-pole, three-position slide switch, see text)
SP1	miniature speaker, 4-8 ohms
U1	CD4011B CMOS quad two-input NAND gate
U2	74C14 CMOS hex Schmitt trigger
U3	CD4023B CMOS triple three-input NAND gate
U4	74C93 CMOS four-bit binary counter
U5	CD4072B CMOS dual four-input OR gate
U6	CD4528B CMOS dual monostable
U7	MK5088 Mostek CMOS Touchtone™ generator
U8,U9	HM3-6562-9 Harris 258x4 CMOS RAM
U10	LM398 audio power amp
U11	two-input AND gate (see text)
Y1	3.58 MHz color-burst crystal, HC18U case

Note:
Capacitors are either dipped tantalum, disc ceramic, or electrolytic, as noted. All resistors 1/4 watt, 5 percent tolerence.

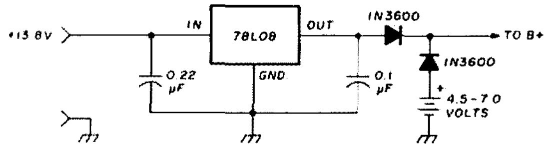


fig. 6. The auto-dialer can be powered by an external 13.8-volt supply if desired, using a battery as backup. Standard silicon rectifier diodes can be substituted for the IN3600's.

operation

Using the dialer is simple. R21 adjusts the tone output level and R19 the monitor volume. For manual operation, just key the dialer — PTT operation is automatic. To program, set S6 to the desired telephone number, switch S1 to PROGRAM, push S5 to reset the counter, and dial in your number just as if you were dialing manually. Program a carrier drop between your access code and telephone number if required by your repeater. You can also add a blank or two between the access code and number to allow time for obtaining a dial tone during dialing. After the last digit, add an END, unless, of course, you've programmed sixteen digits. (An eleven-digit long-distance telephone number, plus a three-digit access code, carrier drop and blank, will not need an END.) Switch back to the RUN mode and push S2 to dial the sequence just programmed. When the monitor volume becomes distorted, lower its volume slightly to restore clarity. When that doesn't work, it's time to change the battery.

manufacturers and component sources

Harris Semiconductor, Box 883, Melbourne, Florida 32901, (305) 724-7430

Mostek Corp., 1215 W. Crosby Road, Carrollton, Texas 75006, (214) 242-0444

Eeco, 1441 E. Chestnut Ave., Santa Ana, California 92701, (714) 835-6000

Cherry Electrical Products Corp., 3600 Sunset Ave., Waukegan, Illinois 60085, (312) 689-7700

Distributors of some of the harder-to-get chips:

Hamilton/Avnet (Harris): (516) 333-5800 (NY)
(714) 279-2421 (CA)

Schweber Electronics (Mostek): (516) 334-7474 (NY)
(714) 556-3880 (CA)

Tri-Tek Inc. (Mostek): (609) 995-9352 (AZ)

Spectronics Inc. (Mostek): (312) 848-6777 (IL)

ham radio

modifications to the Heath model 10-4530 oscilloscope

Simple circuit revision eliminates the dc balance control in this popular instrument

My oscilloscope, built from a popular kit, is an ac-dc 10-MHz instrument that has given me good service for over five years. Specifically, it is a Heathkit model 10-4530. As in most other makes of oscilloscopes of this vintage, it has a balance control to zero the offset voltage of the input stage so that, with no input, the baseline does not move vertically when the gain control is varied. This oscilloscope's balance control is a small, single-turn trimmer mounted on the PC board. Unfortunately, to make an adjustment, the cabinet has to be removed, which doesn't offer much encouragement for keeping the offset voltage zeroed.

I tried replacing the single-turn trimmer with a ten-turn pot and also tried replacing the FETs, but the drift persisted. I was about to install a balance control pot somewhere on the front panel when it occurred to me that I might be able to design a better zeroing circuit. This article describes my solution.

the original circuit

To better understand the problem and my solution, the original zeroing circuit is shown in **fig. 1.** Basically, Q3 is a source follower, which presents a high impedance to the decade attenuator and a low impedance to the 1-2-5 attenuator. It draws about 4 mA and has a gain of about 0.8 at point **A** when the gain control is at its minimum position. Point **A** must be kept at precisely zero volts dc (with no signal input), otherwise any offset at this point will be passed on to the following attenuator as a variable offset as the gain control is varied. By adding a constant-current circuit consisting of Q4 and the dc balance control, an adjustable bucking current equal to the drain current of Q3 holds point **A** at zero potential, theoretically.

Practically, at least in my oscilloscope, point **A** would drift off zero. Temperature changes may have been partly the cause, since the FETs are not operated at their zero-temperature-coefficient currents. FET zero-temperature-coefficient currents are usually about one fourth the actual currents here. Reducing the current of Q3 to its zero-temperature-coefficient current would require adding a relatively large source resistor to develop the required gate bias of around − 1.3 volts. Adding such a source resistor would reduce the follower gain at point **A** to an unacceptable level.

the solution

Obviously what is needed is a voltage follower that has a zero voltage output at zero voltage input. After

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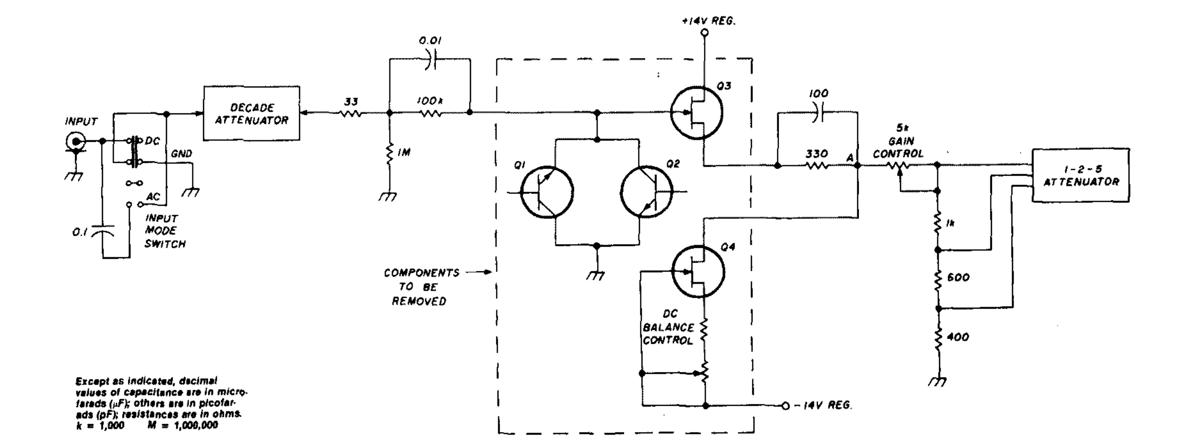

fig. 1. Original circuit of the input stage of the Heathkit model 10-4530. Point *A* should be maintained at zero dc potential with input grounded.

I'd considered automatic zeroing circuits, such as those used in digital voltmeters and other equally complex circuits, my junk box yielded the solution. It is the LM310. This IC is specifically designed for voltage-follower use. Typically, it has an input resistance of 10^{12} ohms, an input bias current of only 2 nA, very low output resistance, supply current of about 4 mA (the same as Q3's drain current — thus not disrupting the original supply circuits), a slew rate of 30V/μs, and a unity bandwidth of 20 MHz. It also has input protection, so Q1 and Q2 are not required. It has pins for offset nulling. Its gain is specified at 0.999. Note that the usual voltage follower connection from the output to the inverting input is not required, since this is accomplished internally in the LM310.

These specifications are ideal for this application with the exception of the input bias current of 2 nA which, if not bucked out, would cause a slight movement of the baseline when switching ranges or when grounding the input with the **AC-GND-DC** switch. This happens because 2 nA flowing through the 1-megohm gate resistor develops 2 mV across it. A 2-mV offset voltage would displace the CRT baseline 0.2 cm when using the 10 mV/cm range. This offset voltage isn't constant because the 1-megohm resistor is shunted by various resistors in the decade attenuator when ranges are switched, and it is shorted when the **AC-GND-DC** switch is used in the **GND** mode. Therefore, the drop across the 1-megohm resistor varies from zero to a maximum of 2 mV when the most sensitive range is used.

A simple bucking circuit cancels the adverse effect of the LM310 bias current. The bucking circuit, as shown in **fig. 2**, applies an opposing current through the 1-megohm resistor. While not completely canceling the offset voltage under all range positions, it reduces the offset to values ranging from zero to 8 μV. This is an insignificant offset that can't be observed on the CRT. **Fig. 2** shows the modified circuit using the LM310.

The original 1-megohm gate resistor has a tolerance of ± 1 percent, since it serves as the lower leg of the input divider when the X10 probe is used. Therefore, when a 22-megohm resistor is added in parallel, it becomes necessary to increase the 1-megohm resistor by 43k, so that the resulting effective input resistor is still 1 megohm. Resistor R6 accomplishes this.

construction

After removing the parts indicated in **fig. 1**, there is just enough room to install the new components. I used a 3/4 by 1 inch (19 by 25.4 mm) piece of perfboard to mount the LM310 with its socket, the R4 nulling pot, R5, C2, and C3. **Fig. 3** shows the component layout. Point-to-point wiring was used on the reverse side. Components R1, R2, R3, R6, and C1 were installed "free-standing." Connections from the five flea clips to the oscilloscope's PC board were made with short wires through holes left in the PC board where components were removed. R5 was needed to reduce the gain to match the lower original gain so that calibration could still be made within the range of the calibration pot in the following stage.

adjustments

Temporarily connect a 100-ohm pot in place of R1 and omit R2. Let the oscilloscope warm up for five or ten minutes. Then with the **AC-GND-DC** switch in the **GND** mode and the range switch in the 10 mV/cm position, adjust R4, the nulling pot, until the CRT

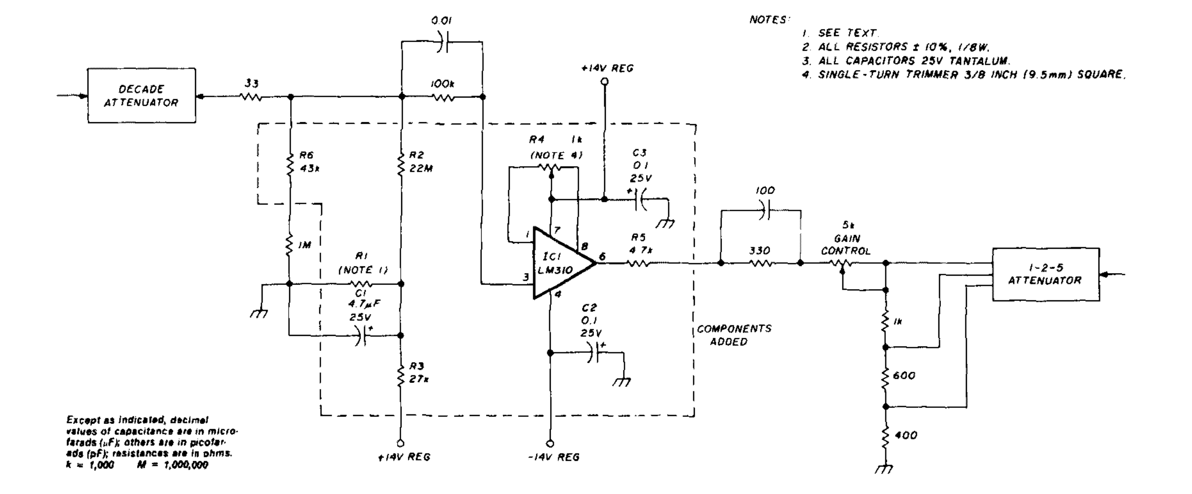

fig. 2. Modified circuit using an LM310 voltage follower. Pin 6 of the LM310 is maintained at zero potential with no input to the oscilloscope.

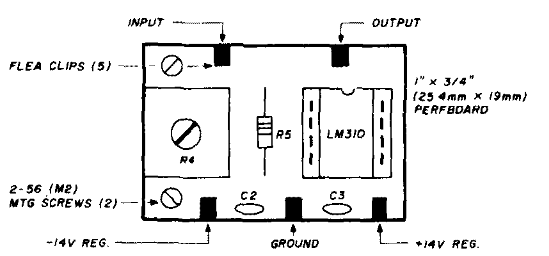

fig. 3. Component layout of the modified input circuit.

baseline does not move vertically as the gain control is varied from minimum to maximum. Next, install R2 and adjust the temporary pot so that the baseline doesn't jump when the **AC-GND-DC** switch is changed from **GND** to **DC**. Then measure the value of the temporary pot and install a resistor of the same value. The value required will depend on the tolerances of R2, R3 and the actual bias current of the particular LM310 used. The value isn't very critical. I found I needed a 62-ohm resistor but I used 56 ohms with excellent results.

additional comments

The Heathkit model 10-4530 has the same circuit at the input of its horizontal channel. This same modification could be used here also but I didn't make that change, principally because it looked rather hard to fit the new parts in the available space.

No attempt was made to minimize temperature effects in this modification. Actually, after a warmup period of five minutes no temperature-related drifts were observed in the room-temperature environment in which my oscilloscope is used.

The LM310 has been around for quite a few years and is readily available from mail order sources (James Electronics at $1.75 for example). Adding the cost of the other parts, the total comes to around $5, which is a very respectable expense for such an effective modification.

After having completed this modification I ran a frequency-response test on the oscilloscope and found it to be well within its specified range of 0 to 10 MHz ±3 dB.

This modified circuit has been in operation now for over six months with no drift, and no adjustments have been necessary.

other oscilloscopes

Owners of oscilloscopes with input-voltage-follower circuitry different from the Heathkit model 10-4530 can, with some study, probably adapt this same modification to their instruments. Typically the second stage will be a differential gain stage with provision for calibration and position adjustments. The first stage will be a voltage follower providing gain and dc balance adjustments as in the Heath oscilloscope. If such is the case in your oscilloscope, merely replace the first voltage follower stage with the LM310 circuit modification described in this article including the input bias current bucking network. Then connect a 5 k pot from LM310's pin 6 to ground with the arm going to the next stage. This provides variable gain with no offset.

ham radio

propagation of radio waves

A discussion of how radio waves travel through space

It's hard to visualize, but at this very instant there are electromagnetic fields all around you, at frequencies from virtually dc to gamma radiation, originating from sources as near as your desk lamp and as far away as distant galaxies. Some are manmade, others natural in origin. Even the energy from an Amateur Radio station in Japan, running perhaps less than 10 watts, may be passing through your body as you read this.

What are radio waves? How do they travel over the horizon? What affects their propagation?

electromagnetic radiation

Any electrically charged particle has an electric field surrounding it. A moving charged particle produces a magnetic field. But an accelerating charged particle — one whose speed is changing — produces

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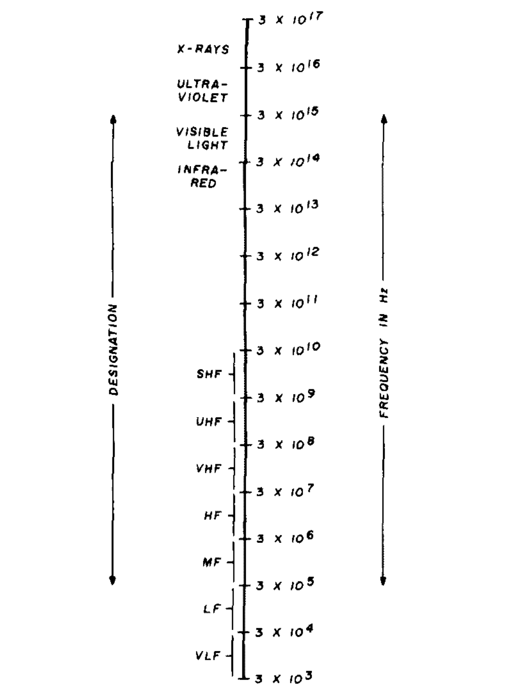

fig. 1. Logarithmic representation of the electromagnetic spectrum.

an electromagnetic field. This kind of field has a way of reproducing itself in such a way that, even at great distances, the electrons in a conductor are accelerated in a manner identical to that of the particles in the far-off antenna. Usually, when electromagnetic fields are produced deliberately for communications purposes, a sine-wave current is generated in a piece of wire. This current may have any frequency, from less than 1 Hz to billions of Hz.

the electromagnetic spectrum

Electromagnetic fields can have almost any frequency except zero. Radio and television signals have frequencies between about 10 kHz and several GHz. As the frequency is increased past the radio range, we get infrared, visible light, ultraviolet, and X-rays. **Fig. 1** shows a logarithmic diagram of the electromagnetic spectrum from 3 kHz to 3×10^{17} Hz (300 quadrillion Hzl).

Radio waves are categorized as VLF (very low frequency), MF (medium frequency), HF (high frequency), VHF (very high frequency), UHF (ultra high frequency), and SHF (super high frequency). **Fig. 1** shows where these designated ranges fall relative to the rest of the electromagnetic spectrum.

Radio waves, and all electromagnetic fields, tend to travel in straight lines. There are factors that bend radio waves, however, and it is fortunate that this is so. Otherwise, radio communications as we know it would be impossible. Let's look at the various ways that electromagnetic energy fields are affected by the environment. Then we'll examine how the effects change with changing frequency.

Radio waves can be bent by ground conduction, the ionosphere, and by tropospheric disturbances. These effects are usually referred to as ground-wave, sky-wave, and tropospheric propagation, respectively.

the ground wave

At some frequencies, signals tend to follow the earth for great distances. The ground actually forms a part of the circuit, acting like a wire and transferring energy. This kind of propagation occurs when the electric lines of force are vertically polarized, as shown by **fig. 2A**. Ground-wave propagation is best at low frequencies, and gets progressively less efficient at higher frequencies.

the sky wave

Sky-wave propagation is the familiar effect that permits us to listen to distant stations on the am broadcast band and on the shortwave bands. Ionized layers of the upper atmosphere cause the electromagnetic energy to be bent back down to the earth, which facilitates over-the-horizon communications. There are four different layers of ionization that affect radio energy: the D layer at a height of about 45 miles, the E layer at about 65 miles, the F1 layer at about 100 miles, and the F2 layer at about 130 to 260 miles. These layers fluctuate somewhat in altitude and thickness; they are illustrated in **fig. 2B**. The F1 and F2 layers usually merge into a single layer, the F2 layer, during the hours of darkness.

Ionospheric effects vary tremendously with frequency. We will look at these phenomena shortly.

tropospheric propagation

At certain wavelengths, the atmosphere itself can bend the path of an electromagnetic field. Sometimes this occurs as refraction, in which case it is called "tropospheric bending" (**fig. 2C**). Tropospheric bending tends to spread a beamed signal, as shown. Bending takes place near a frontal system, where cool, dry air is overlaid with warm, moist air.

Occasionally, the boundary between two air masses is so well defined that actual reflection occurs. This is called "ducting." Ducting may occur between the ground and the plane dividing two air masses, or it may occur between two air-mass boundaries (**fig. 2D**).

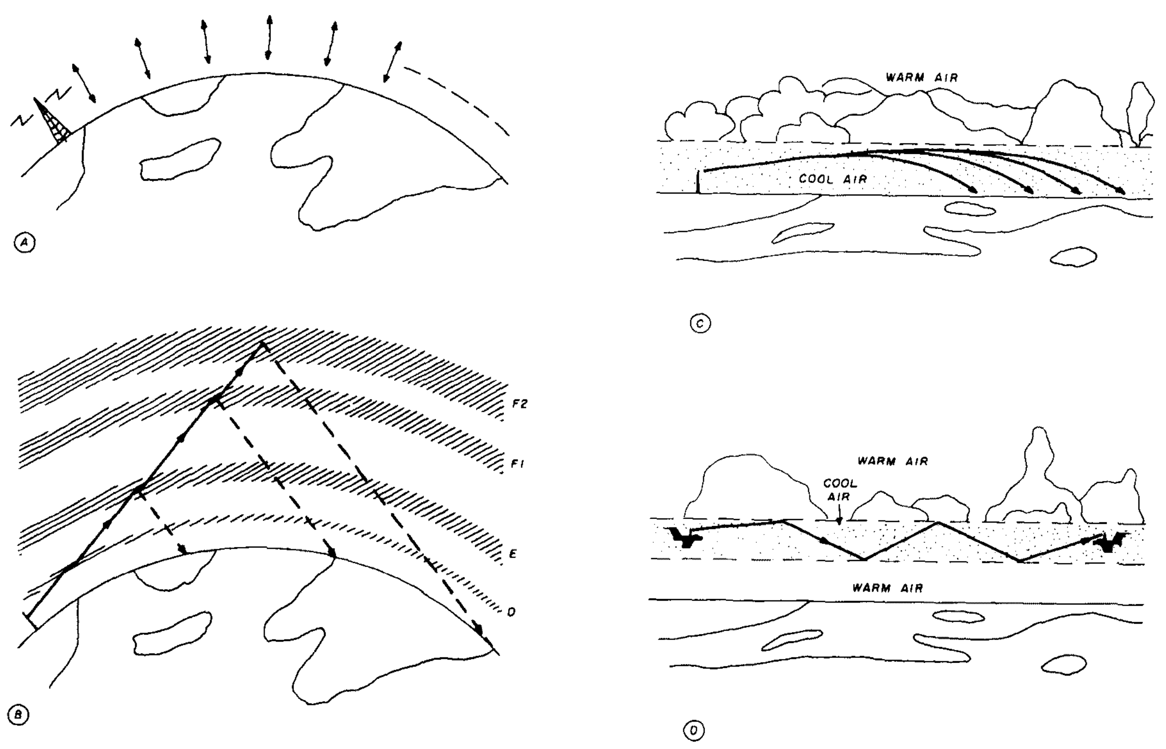

fig. 2. (A) Ground-wave propagation of vertically polarized waves; (B) sky-wave propagation; (C) tropospheric bending; and (D) ducting.

propagation at VLF and LF

Let us construct an imaginary transmitting station, and raise the frequency gradually while we investigate the effects of the ground, ionosphere, and troposphere. We'll start at 3 kHz, the low end of the VLF band, and progress into the UHF and SHF.

At VLF (3 to 30 kHz)* and LF (30 to 300 kHz), propagation occurs via ground wave and sky wave. There is no tropospheric bending or ducting.

In this frequency band, electromagnetic fields are "trapped" between the F2 layer and the earth, in much the same way as sound travels in a large room with a low ceiling. All energy reaching the F2 layer is returned to earth, except for a small loss to heating of the ions. The earth reflects signals back up into space. It's like a huge echo chamber.

At certain times, the D layer gets in the way of this, somewhat like the effect of a suspended cotton sheet midway between the floor and ceiling. The D layer absorbs energy, preventing it from bouncing back and forth indefinitely between the ground and the F2 layer. D-layer absorption is more severe during the daytime than at night, and increases toward the upper end of the VLF/LF range. During solar flares, the D layer may totally wipe out communications via sky wave at VLF and LF.

Ground-wave propagation is very good at VLF and LF. A vertically polarized signal can travel thousands of miles at VLF and hundreds of miles at LF, although high power and huge antennas are required. Since ground-wave propagation has nothing to do with the ionosphere, the VLF and LF bands may prove valuable on planets that don't have any ionosphere and hence no sky-wave propagation. Ground-wave signals do not fade; such a circuit is just about like a telephone hookup.

propagation at MF

The MF range extends from 300 kHz to 3 MHz. As we raise the frequency of our imaginary transmitter above 300 kHz, we find that ground-wave propagation gets less and less efficient. The earth, which acts as a good conductor at VLF and a fair conductor at LF, begins to get lossy at MF. By the time we reach 3 MHz, the ground wave dies out after it has traveled only about 100 to 150 miles.

*Some sources say VLF is 3 to 30 kHz, others say 10 to 30 kHz.

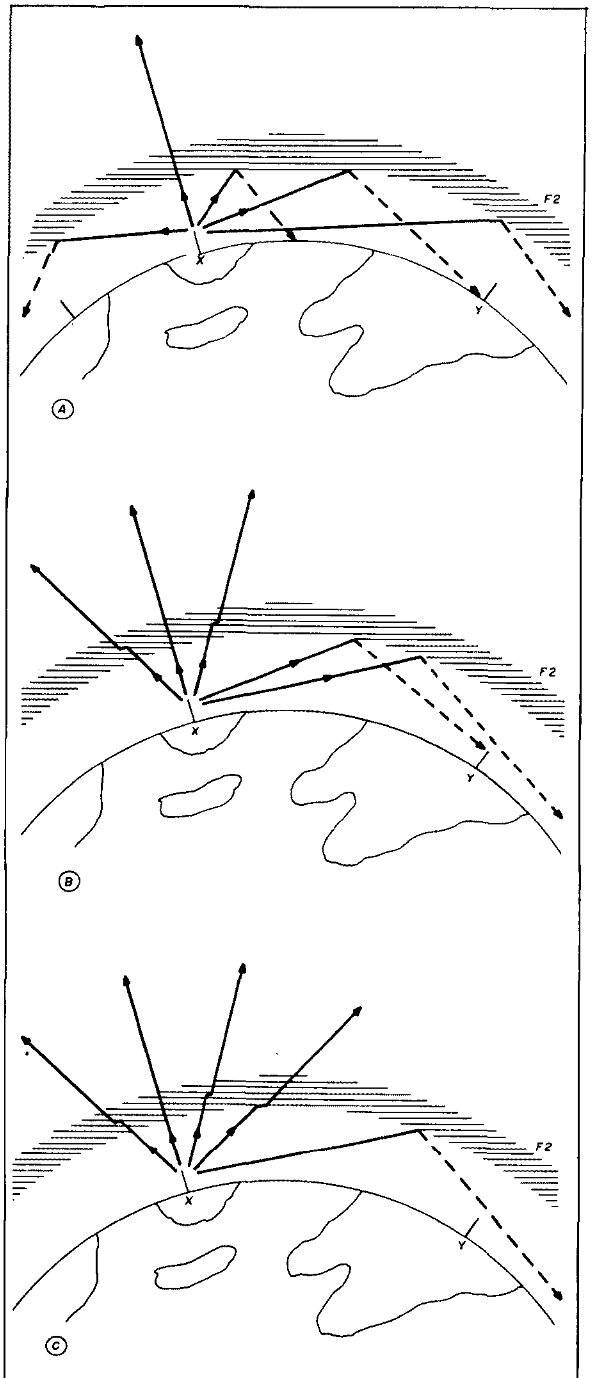

fig. 3. (A) critical frequency; (B and C) as frequency rises, more energy escapes into space.

Sky-wave propagation, however, continues. The F2 layer returns all signals in the MF range, provided the D layer does not interfere. But the D layer absorbs MF signals with relentless efficiency during the daytime. Consequently, the range is limited until the sun goes down. Then things get interesting!

Once dusk falls, the D layer quickly disappears, because at that altitude the atoms don't remain ionized unless they are constantly bombarded by ultraviolet light. The MF signals then reach the F2 layer, and worldwide communications become possible. As we get up towards 3 MHz, propagation gets better at night. The size of an efficient transmitting antenna is reasonable in the MF range, so it is no longer necessary to run hundreds of kilowatts to get long-range reliability.

At MF, there is still no tropospheric effect. The radio waves ignore the atmosphere completely.

propagation at HF

The HF band is the range of frequencies generally called "short waves." At 3 MHz, all signals that reach the F2 layer are returned to the earth. But as we climb in frequency, a point will be reached where not all signals come back. Signals sent straight up will be the first to escape into space. At a frequency called the "critical frequency," signals sent vertically upward will not return, but all others of lower frequency will (**fig. 3A**).

The critical frequency may be as low as 4 or 5 MHz or as high as 8 to 10 MHz, depending on the density of the F2 layer. In general, the greater the density, the higher the critical frequency. F2 density is a function of the level of solar activity. This varies from day to day, but in general it follows a cycle lasting about eleven years from peak to peak. We are just passing a sunspot maximum now, and will reach another peak in about 1991. The next minimum will come in 1986 or 1987.

As we continue up from the critical frequency, energy at lower and lower angles will escape into space (**figs. 3B** and **3C**). Also, as we raise the frequency, the ground wave gets more and more anemic until, at 10 MHz, it extends hardly past the visual horizon. Above 10 MHz there is no ground wave for all practical purposes.

In **fig. 3C**, communications between points X and Y is impossible. The sky wave does not come back to the earth until well beyond point Y; within this limit, the angle of incidence at the F2 layer is too large. The ground wave dies out long before it reaches point Y. Viewing this situation from above (**fig. 4**), we see that there is a zone where signals from X cannot be heard. The inner dotted area represents the range of the ground wave, and the cross-hatched area represents the region where the sky wave is returned to earth. The quiet zone is called the "skip zone" because signals skip over it.

As we raise the frequency still more, the skip zone gets wider and wider until finally no signals are re-

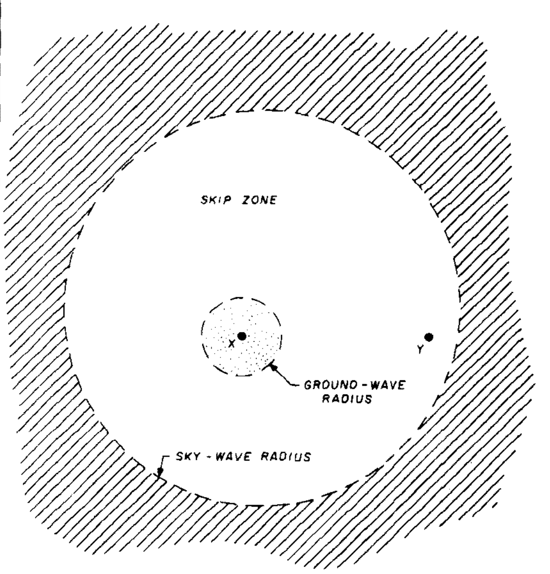

fig. 4. The skip zone, viewed from above.

turned to earth via the F2 layer. We have reached the highest frequency at which F2 communications is possible. Like the critical frequency, this frequency depends on the amount of ionization in the F2 layer. The "maximum usable frequency," as this is called, may be as low as 7 or 8 MHz on a winter night during a sunspot minimum; on a few occasions it has been as high as 70 MHz.*

As we get into the upper HF range, D-layer absorption decreases to the point of insignificance. The troposphere begins to have some effect on radio waves. Occasionally, at the upper end of the HF band, "patches" of high-density E-layer ionization allow communications up to several hundred miles. This is called "sporadic E" propagation. It usually occurs during short periods of exceptionally high solar activity.

propagation at VHF and above

As we progress higher in frequency, F2-layer propagation gets less common until, above about 70 MHz, it never happens. However, sporadic-E is possible up to 120 or 140 MHz, and openings via this mode are frequent if short-lived. There is no D-layer absorption at VHF and above, so daytime communications are just as good as at night.

At VHF, the effect of the troposphere is very important in long-distance communications. When a warm air mass overruns a cool one (warm front) or a cool air mass pushes underneath a warm one (cold front), tropospheric bending usually occurs. Cool air, being denser, has a higher index of refraction for VHF energy. This bends the waves back down toward the earth as shown in **fig. 2C**. (Sound waves over a still lake behave in a similar way. This is why you can sometimes hear people talking thousands of feet away on the lakefront.)

Tropospheric bending can take place over ranges exceeding 1000 miles. The best conditions between two points for "tropo" are near a frontal system forming an approximately straight line passing on the same side of both points, and so that both points are within the cool air region. Tropo is common over large bodies of water, which cool the air near the surface during the daytime.

The other, and less common, form of tropospheric propagation is known as "ducting." When a cool air mass is sandwiched in between two warm ones, or when the boundary is very sharp between two air masses, reflection takes place at the boundary. For communications to be possible via a duct, both the receiving and transmitting antenna must be within the duct, and the duct must exist at all points between the two antennas. In **fig. 2D**, two airplanes can communicate over the horizon because there is a duct between them.

Bending and ducting are possible well into the UHF region — exceeding 1 GHz. As we raise the frequency ever higher, dust particles and water droplets begin to have an attenuating effect. Eventually, even the air itself degrades propagation. At some frequencies we will find the atmosphere almost opaque because of absorption. If we keep going higher, we finally reach the infrared, visible light, ultraviolet, and X rays (**fig. 1**).

exotic forms of propagation

We have traversed from 3 kHz, a frequency so low that connecting headphones directly to the antenna may yield an audible tone, to trillions of Hz, where the wavelength is microscopic. Over this entire range, the common forms of over-the-horizon propagation are ground-wave, sky-wave, and tropospheric. But long-distance communications can be accomplished by other means, more unusual but still significant and useful. These strange effects include aurora, meteor scatter, moonbounce, and subterranean propagation.

Aurora. Aurora is caused by intense solar disturbances. An auroral display is usually accompanied by total disruption at HF and below because of absorption by the D layer. Above about 20 to 30 MHz, however, signals can be reflected off auroral curtains. If

*The precise definition of maximum usable frequency varies. It may be defined based on two specific points on the globe, such as X and Y, or it may be defined independently of the receiving point, as it is here.

two stations both point their antennas at the same part of the aurora, they can communicate. This is shown in **fig. 5A**.

Auroral communications is accompanied by rapid fading of extraordinary proportions. The motion of the aurora causes a severe Doppler effect, spreading the signal out over as much as several hundred Hz. Multipath propagation (illustrated by the dotted and solid lines) can cause fading so rapid that voice-modulated signals sound as if the other person is speaking through an electric fan. A CW carrier, though readable, may sound like a warbling hiss.

Of course, both stations must be at latitudes high enough to take advantage of auroral effects.

Meteor scatter. When a meteor enters the upper atmosphere, it leaves an ionized trail. At VHF, two stations whose antennas are both aimed at this trail may communicate for several seconds. When there is a meteor shower, usable trails may exist for a large enough proportion of the time so that a conversation may be carried on. Meteor scatter is also accompanied by multipath effects (**fig. 5B**).

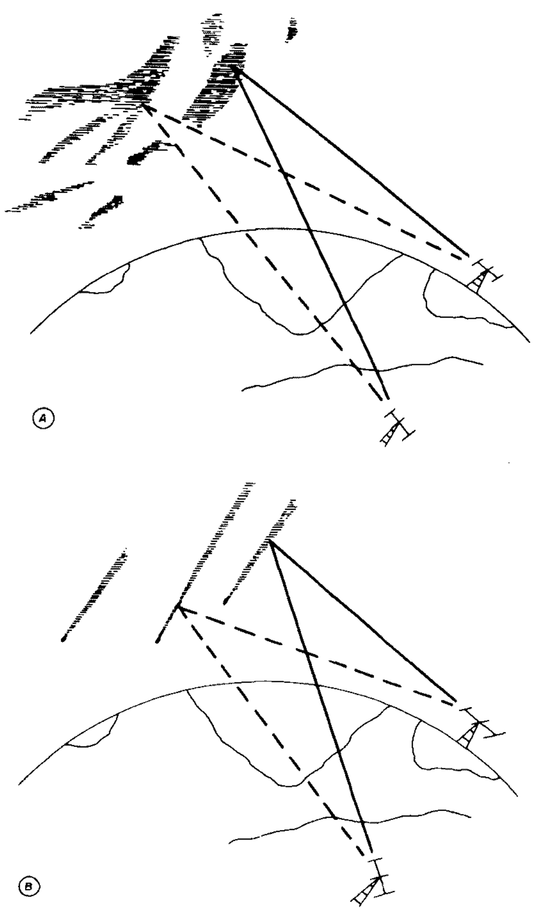

fig. 5. (A) auroral propagation, and (B) meteor scatter.

Moonbounce. Does this sound like something that requires a radio telescope and hundreds of kilowatts? Well, it has been done by Radio Amateurs with only 1000 watts and relatively modest antenna systems. Moonbounce is possible at any frequency that will get through the ionosphere, but VHF and UHF are the most commonly used frequencies for this mode, since it is easy to construct antennas with high gain for those frequencies.

Some Radio Amateurs have clock-driven, equatorial-mount antenna arrays so they can communicate via moonbounce for hours at a time.

Subterranean propagation. This is perhaps the strangest mode of all. The entire planet, being finite in size and a fairly good conductor at low frequencies, has a resonant frequency at which alternating currents bounce around inside the globe and reinforce each other. The military is already experimenting with subterranean propagation for the purpose of communicating with submarines. Subterranean propagation requires huge antenna systems (if you can really call them "antennas") and a lot of power. It is not something for the backyard experimenter!

conclusion

Would you expect to hear a Middle Eastern broadcast station on 9.6 MHz at 10:00 AM EST in New York? How about a Radio Amateur from Australia at 6:00 PM on 21 MHz? Would you expect to hear "skip" (a misnomer) on CB in the middle of the night in 1986? You should be able to answer these questions for yourself, based on the information here. You will be less likely to waste time listening for stations whose signals aren't getting to you, once you understand the propagation characteristics of the particular band.

Of course, there are exceptions to the rules in any game, and Mother Nature's game often takes time out. I have contacted a ham in the USSR from Miami on 7 MHz at high noon local time, while running just 100 watts from my modest station. Sometimes you'll hear AM broadcast stations from hundreds of miles away during the daytime, or signals that should be in the skip zone may come in S9 plus. I'm glad the old lady is a little eccentric.

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ham radio

biasing Class-A bipolar transistor amplifiers

Simplified approach to transistor biasing including a sample problem using load lines

The common-emitter amplifier is one of the most familiar circuits in use, but the procedure for biasing the amplifier for Class-A operation is not so well known. Over the past few years I have condensed what I've learned in the classroom and hamshack into the simple six-step procedure described in this article. I've found this procedure to be faster than cut and try methods and more tolerant of circuit parameter changes (such as temperature, power-supply voltage and transistor replacement). The procedure is based on several good engineering guidelines, yet it requires no mathematics more complicated than long division. It is ideal for Amateur projects.

I use the circuit of **fig. 1**. The transistor is operated as a Class-A amplifier in the common-emitter configuration. Resistors *R1*, *R2*, *R3*, and *R4* establish the dc operating point (bias) for the transistor. The capacitor does not affect the biasing and will be discussed separately. The task at hand is to select values for the four resistors based on the transistor type, power-supply voltage and collector current. **Table 1** lists transistor circuit parameters used in the following discussion.

biasing procedure

1. Choose the transistor type, power supply voltage and collector current. I usually select a transistor from my junkbox that can operate at the desired frequency and power level. Look up or measure the β of your transistor. Some reference manuals will list the h_{fe}, which is close enough to β for our purposes. If you're not able to calculate the collector current that you require, use something between 1 and 20 mA. You will probably get by. The 2N2222A, having a β of about 200, drawing 10 mA from a 13.8-volt supply, is a typical choice that will operate into the MHz region.

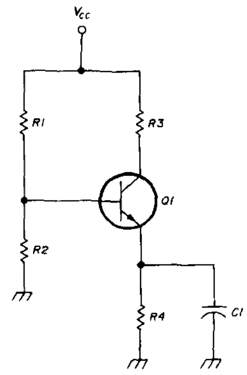

fig. 1. Circuit used for calculating transistor bias parameters as discussed in the text.

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table 1. Transistor circuit parameters.

parameter	definition
β	Large-signal current gain of a common emitter transistor.
h_{fe}	Small-signal current gain. In this article, β and h_{fe} are considered to be approximately equal.
I_b	Current flowing into the base terminal.
I_c	Current flowing into the collector terminal.
I_e	Current flowing out of the emitter terminal (in this article).
I_{r2}	Current flowing through R2.
V_b	Voltage measured from the base terminal to ground.
V_{be}	Voltage measured between the base terminal and the emitter.
V_{cc}	Power supply voltage (in this article).
V_{ce}	Voltage measured between the collector terminal and the emitter.

2. Calculate $R3 = (V_{cc} - 3.5)/(2I_c)$.

3. Calculate $R4 = 3.5/I_c$.

4. Calculate $I_{r2} = 5I_c/\beta$. This current is required to perform the following calculations.

5. Calculate $R2 = (I_c R4 + 0.7)/I_{r2}$.

6. Calculate $R1 = (V_{cc} - 0.7 - I_c R4)/(I_{r2} + I_c/\beta)$.

theory

The bias network must be designed so that the amplifier will operate over a wide range of temperatures and power-supply voltages, and tolerate replacement of the transistor. Mobile equipment, in particular, is subject to environmental extremes. It is not uncommon to encounter variations in β of 2:1 or more between different transistors of the same type. The circuit of **fig. 1** was chosen because it addresses all of these problems.

Stability considerations[1] suggest that $I_e R4$ be greater than or equal to $5V_{be}$, and I_{r2} be greater than or equal to $5I_b$. Since V_{be} for a silicon transistor will be about 0.7 volt, $I_e R4$ will need to be at least 3.5 volts to meet the first consideration. This should be the potential measured at the transistor's emitter terminal. Note that I_c is approximately equal to I_e. This allows the substitution of I_c for I_e in the first stability consideration and the resultant calculation of $R4$.

The remainder of the power-supply potential (that which does not appear across $R4$) is equally divided across the transistor's CE terminals and $R3$. This is sufficient information to calculate $R3$.

The value of I_{r2} is calculated to meet the second stability consideration. The required value of I_b will be I_c/β if the transistor's leakage current is neglected. $R2$ is calculated as soon as the potential at the transistor's base terminal, $I_c R4 + 0.7$, is determined. Finally $R1$ is calculated to pass $I_{r2} + I_b$ across a voltage drop of $V_{cc} - V_b$.

selecting the capacitor

The capacitor is not a conductor of dc and was neglected during the biasing calculations. However it plays an important role in determining the low-frequency response of the amplifier. The capacitor must be selected to present a low impedance path to ground from the emitter terminal at the lowest frequency of interest. The procedure to derive the exact capacitance required is beyond the means of many hams because it involves a transistor parameter not generally available in Amateur references. I have had some success choosing a capacitor whose reactance at the lowest frequency of interest is one tenth the resistance value of $R4$.

an alternative method: using a load line

The transistor's common-emitter collector characteristics, when available, may be used to construct a popular aid known as the load line.[2] The load line is a graphical device used to select the collector current, I_c, and load resistance, $R3$, that maximizes the amplifier's signal-handling ability. This suggests that the load line is most useful when the magnitude of the output signal becomes a significant portion of V_{cc}, and its use is probably a waste of time at low levels. Use of the load line replaces steps 1 and 2 of the procedure described earlier and yields calculated values of I_c and $R3$ as opposed to $R3$ alone. The calculation of I_c is the source of improvement.

Fig. 2 illustrates a typical set of curves for a transistor in the common-emitter configuration. Their

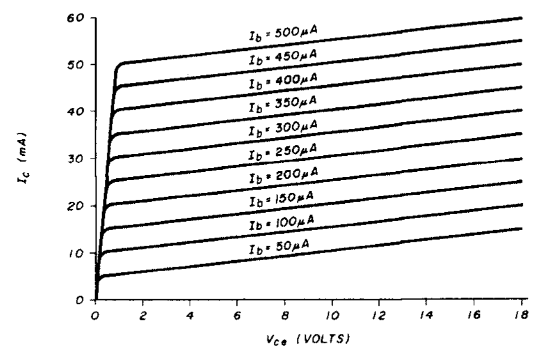

fig. 2. Collector current, I_c, as a function of collector-to-emitter voltage, V_{ce}, with base current, I_b, as a parameter in the common-emitter configuration.

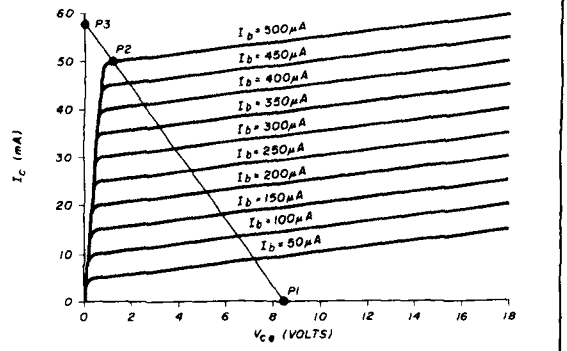

fig. 3. Biasing procedure using load lines, showing method of locating points P1, P2, and P3 as described in the sample problem.

examination reveals that the collector current, I_c, is being plotted against the collector-emitter voltage, V_{ce}, at various base currents, I_b. Actual common emitter characteristics vary from transistor to transistor of the same type and exhibit a marked shift with temperature; thus they are approximate.

Recall that the biasing procedure will develop 3.5 volts across $R4$, placing the emitter 3.5 volts above ground. This establishes the maximum collector-emitter voltage, $V_{ce}\ max$, as $V_{cc} - 3.5$ *volts*. Plot this point, *P1*, on the abscissa as shown in **fig. 3**.

Plot a second point, *P2*, just to the right of the knee of one curve. The higher the point is placed on the chart, the higher will be the collector current, signal-handling ability and dissipation. The exact position of the point is your design decision. The point in **fig. 3** has been positioned for maximum signal-handling ability. The collector current at P2 is the expected peak value under maximum signal conditions. Distortion may result if P2 is placed on the knee, because this is the region where the transistor begins to saturate.

Draw the load line from P1, through P2, to the ordinate. Plot point P3 at the intersection of the load line and the ordinate as illustrated in **fig. 3**. P3 is a construction point that will be used in the calculation of $R3$.

Plot point P4 at the intersection of the load line and the bottom curve as shown in **fig. 4**. The collector current at P4 is the expected minimum value under maximum signal conditions. Zero is not used, as unwanted distortion would result from the transistor approaching cutoff.

Plot point P5 midway on the loadline between P2 and P4. The collector current at P5 is the expected idling current under no-signal conditions. The idling collector voltage will be 3.5 volts (developed across $R4$) plus V_{ce} at P5.

Calculate:

$$I_c = I_{P5}$$

$$R3 = (V_{cc} - 3.5)/I_{P3}$$

where: I_{P5} is the collector current at P5 and I_{P3} is the collector current at P3.

These are the calculated values for I_c and $R3$, which will permit the amplifier to deliver its largest signal while remaining in the Class-A mode of operation.

Calculate the remaining resistor values by following steps 3 through 6 of the biasing procedure.

sample problem

The loadline of **fig. 4** is constructed for a hypothetical transistor operating with $V_{cc} = 12$ *volts*. P1 through P5 are plotted as described earlier.

The operating point, P5, suggests that the transistor's collector current, I_c, be set at 30 mA for maximum signal-handling ability. V_{ce} will then be 4.25 volts. The product of these two numbers indicates that the average dissipation will be 128 mW. β may be approximated by dividing the collector current at P5 by the base current. This transistor has a β of about 110. $R3$ is calculated to be $8.5/0.058$, or about 150 ohms.

If the load line had not been used, I would have chosen $I_c = 10\ mA$ and calculated $R3$ to be 425 ohms. The resulting amplifier would certainly operate, but without the signal handling ability of the load-line design. While this may not be important in an early stage of a speech amplifier, it surely would be in a Class-A driver for a higher-power stage.

The remaining resistors and I_{r2} are calculated as follows:

$$R4 = (3.5)/(0.03) = 116.7\ ohms\ (use\ 120\ ohms)$$

$$I_{r2} = (5)(0.03)/(110) = 1.36\ mA$$

$$R2 = [(0.03)(120) + 0.7]/(0.00136) = 3161.8\ ohms\ (use\ 3000\ ohms)$$

$$R1 = [12 - 0.7 - (0.03)(120)]/(0.00136 + 0.03/110) = 4716\ ohms\ (use\ 4700\ ohms)$$

The resulting amplifier will be characterized by low impedances and high currents, dissipation, and signal-handling ability.

drawbacks and limitations

Nothing has been said about gain or input impedance. The entire procedure was developed on the basis that you must take what you can get. While this is satisfactory for simple projects, a more demanding application might employ feedback to stabilize the amplifier.[3]

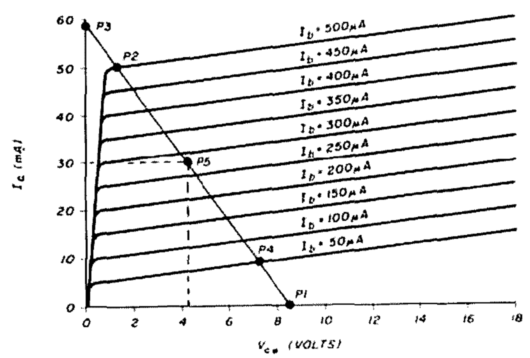

fig. 4. Point P4 locates the minimum collector current, I_c, under maximum signal conditions. Point P5 locates expected idling current under no-signal conditions.

In the procedure I assume the power supply will be able to deliver several times the emitter voltage of 3.5 volts, and everything is meaningless if this is not true.

Some older transistors having a low β, and germanium transistors require considerations which were not addressed.

The stability considerations involve a number of trade-offs. A more exact procedure might deliver better performance for a well-defined operating environment. Such a procedure is given in a step-by-step fashion in reference 1.

The loadline technique fails to take into account the input resistance of the following stage.

The loadline technique treats *R4* as a voltage source, which reduces the effectiveness of the design when I_c drifts from its design point. However, this is not considered to be important in Amateur work.

Common emitter characteristic curves are not found in every semiconductor guide. Reference 4 is one guide that does include them for many transistors.

conclusion

I have presented a simplified approach to the often mysterious subject of transistor biasing. A number of assumptions were made to develop that simplicity, but I feel that the method described here is better than none at all.

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ham radio

an expandable
microwave network
for multimode communications

Basic concepts for future development of a nationwide communications system

The projected network described in this article was originally conceived with the purpose of interlinking communities and cities on a broadband basis. Numerous other capabilities, however, were soon visualized and included to permit almost direct compatibility with future expansions. The resultant communications network is a highly flexible system that may be implemented between adjoining communities, with additional networks in other areas interlinked as desired. Communications modes that can be handled by the network are almost unlimited.

network philosophy

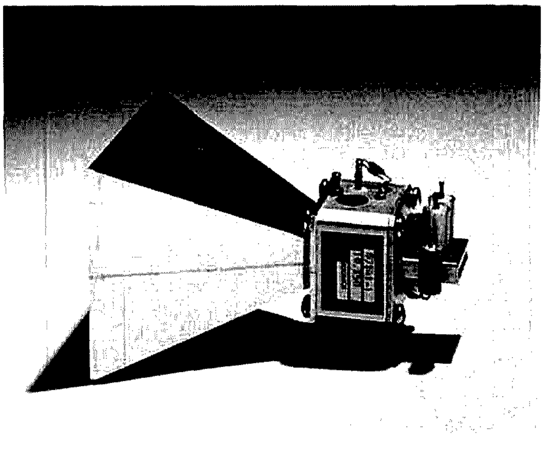
A basic outline of the microwave network is shown in fig. 1. The primary purpose of the network is to provide emergency communications between areas, or cities, separated by a distance greater than the normal 2-meter communications range. Secondary communications capabilities should be considered at installation time, however, since path losses and over-all network bandwidth are directly related. The number of "dumb," or passive, microwave repeaters will be determined by distance and terrain between associated cities, each accepting responsibility for its own part of the link. Existing 2-meter repeater groups and councils can provide finances and frequency/code coordination, respectively.

Two transceivers are shown connected to each microwave port, one preset on the primary frequency and the other scanning a range of approximately 1-MHz of the 2-meter band. (Exception: all secondary transceivers *realize* primary-frequency lockout). Secondary transceivers are under microprocessor control, permitting frequency scanning, spread-spectrum operation, and tone control of transceiver functions (enable/disable, lockout, connect to mailbox, and so forth). The network could initially develop between any two agreeing areas (each preferably with at least two local 2-meter repeaters, as this would confine costs of microwave link additions).

Additional areas could join the existing network by financing their part of the system while extending their benefits to existing network users. Assuming a similar network is also implemented in other areas, more systems may grow until an overall network merger is warranted and implemented. Additional networks may, likewise, grow and merge with the existing system as desired. Further expansions may include spurs and subnetworks as desired.

satellite interlinking

Continuing the network a step further, interlinking with the OSCAR Phase IV geostationary satellites could provide full-hemisphere to complete-world coverage for compatible mode users (projected data 1986). The outline for this concept is shown in **fig. 2**. OSCAR Phase IV is slated to include several features applicable for data communications. Some of these features are dedicated channels, tone controlling, and mailboxing. In some instances, a microwave net-



The 10-GHz Gunnplexer features bandwidths in excess of 20 MHz and direct adaptability to multi-unit linking. Transmitting frequencies of communicating units are offset by the amount of the desired i-f.

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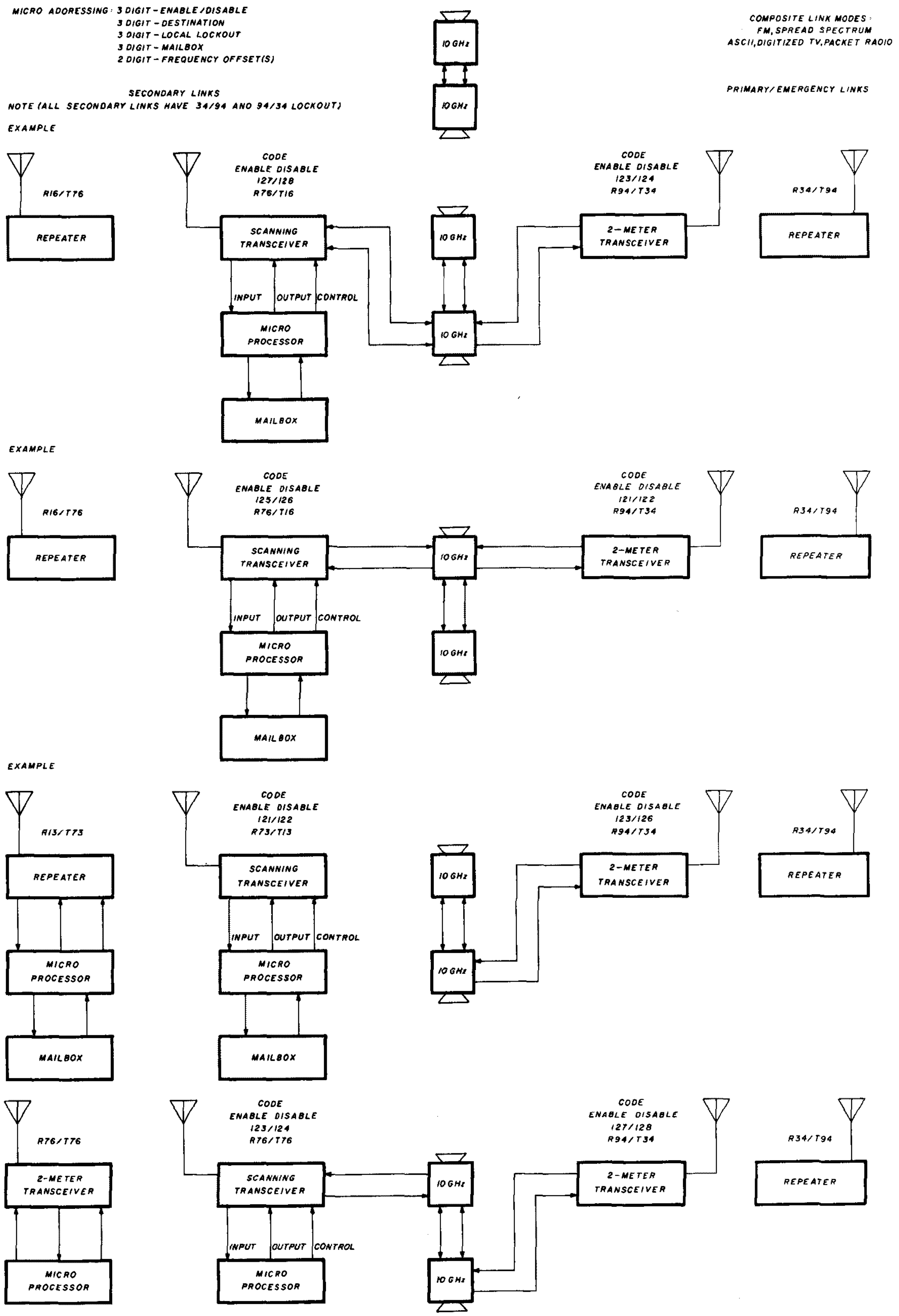


fig. 1. Suggested national microwave network for providing emergency communications between areas separated by a distance greater than normal 2-meter coverage.

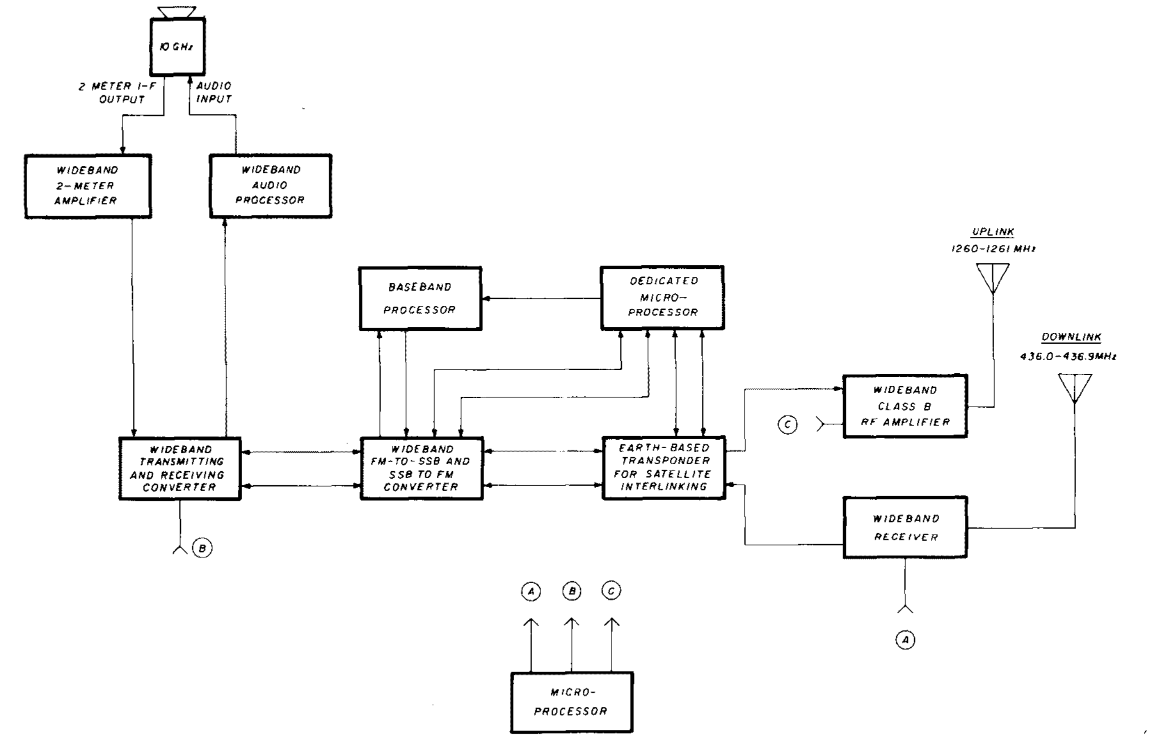


fig. 2. OSCAR Phase IV interlink for a national microwave network. Compatibility is ascribed to PLL-SSB concepts. Master microprocessor monitors "control frequency" of 2 meters and activity of 2-meter bandpass to enable satellite link if a pre-established count of signals on the downlink, uplink, and 2-meter bandpass are not exceeded. If justified, proper follow-up sequence of 2-meter control signals will access the satellite link.

work port may interface with an OSCAR earth-based transponder. At other times, a separate network-to-satellite earth-based station will be required. The criteria will, naturally, be determined by geographic locations of microwave links.

OSCAR satellites necessarily use narrowband modes such as SSB or CW; however, a microwave network should use a constant-carrier mode such as fm. The key to compatibility between these modes is constant-amplitude single sideband, or merely PLL-SSB. This concept, which was developed in Europe four or five years ago, employs a variable amplitude in the normally suppressed carrier. Carrier amplitude is miniscule during modulation, but increases to full power during breaks of speech (after passing through the microwave network, the carrier may be fully removed, resulting in conventional SSB). Finally, total microprocessor control is employed for the link, its preprogrammed functions being available for call-up by coded tones.

technical aspects

The concepts associated with microwave links are, in several respects, unlike those employed in conventional VHF repeater links. Bandwidths of microwave systems, for example, are typically 0.5 to 4 MHz. Output power levels are noticeably lower, with large parabolic dishes providing signal gain capabilities. Conventional superheterodyne techniques are also altered: each microwave transmitter runs continuously, with a small portion of its output power being directed to its receiver's front end to provide a local-oscillator signal. Transmit frequencies of communicating units are then offset by a difference equal to the desired i-f (center frequency). This arrangement may be visualized with the aid of **fig. 3**.

All microwave units are originally transmitting on their hypothetical resting frequency. An incoming signal on 146 MHz shifts the transmitting unit 146 MHz. (A second signal on 146.50 MHz and a third signal on 146.80 MHz would appear as subcarriers of the original signal, until the 146-MHz signal disappeared. The 146.80-MHz signal would then be a subcarrier of the 146.50-MHz signal.) Assuming a "dumb" relay is required between ports, it would receive the 2.246-GHz signal, convert it to 146 MHz, amplify it, and apply it to the associated transmitter. The 2.246-GHz signal would then be received at the

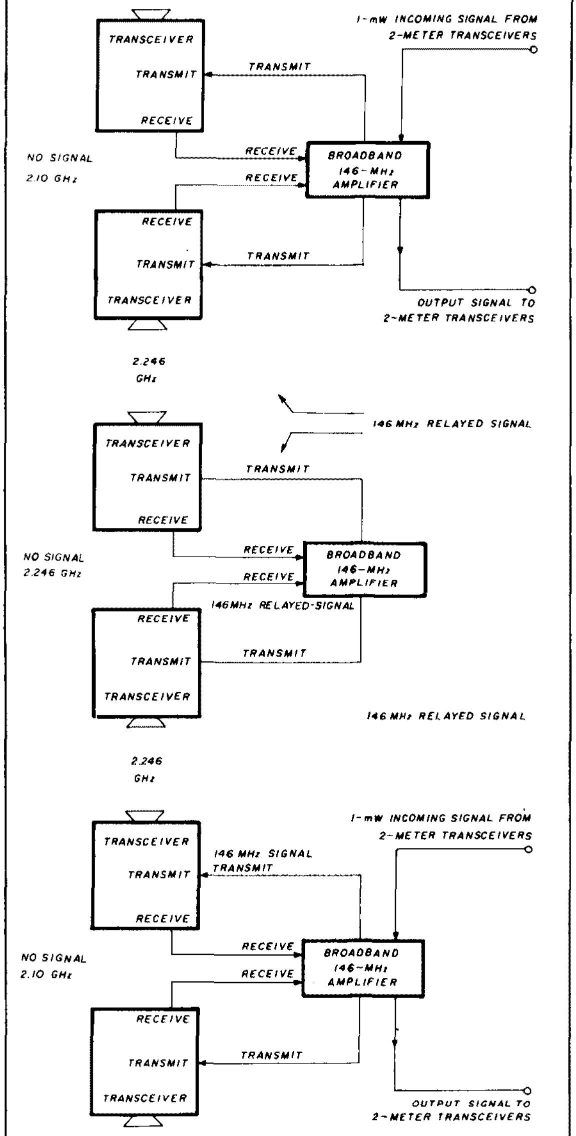


fig. 3. Operational concepts of the national microwave network. Middle unit is considered a "dumb," or passive, repeater with intelligent ports located in large cities.

subsequent microwave port, converted to 146 MHz and applied to a broadband amplifier. That i-f amplifier's output would feed the next 2.10-GHz transmitter and the 146-MHz transceiver (while also accepting 146-MHz band input signals from the 146-MHz transceiver). The microwave system's overall bandwidth could easily expand to 1 MHz, as necessary, with all data/tones being moved in a conventional manner. All operations and frequency determinations of network-located 2-meter transceivers are under microprocessor control. This means that port-available signals may be selected or rejected by tone control, as desired. Preprogramming of the microprocessor establishes basic network standards.

Two microwave bands are prime candidates for network links: 2.1 GHz and 10 GHz. Gunnplexers are readily available for 10-GHz systems; however, their individual-link range is limited.*

operation

Referring to **fig. 1** and applying previously acquired knowledge, a brief discussion of systems operation is presented.

Assume an Amateur operating on 146.76 MHz desires to contact a distant repeater on 146.76 MHz. A 146.76-MHz signal with PL capability and tones of 1, 2, 3 are used for connecting the scanning transceiver into the network. Notice the distant 146.94-MHz transceiver employs lockout, which prevents accidental access. Another three-digit code (1, 2, 7) brings up the desired distant 146.76-MHz scanning transceiver, with subsequent microprocessor control establishing operating parameters for processing that area's 146.76-MHz repeater. Assuming the distant Amateur desires disconnection from the link (or the calling station desires distant disconnection), another three-digit code will bring down that transceiver (example: 1, 2, 8). Data packets may be moved either to the distant repeater or left in the electronic mailbox as required.

Continuing overall system capabilities one step further, we can use tone control and port-located microprocessors for handling frequency offsets and spread-spectrum hopping sequences. This capability would permit an individual Amateur operating on 146.52 MHz to catch the network's scanning transceiver, establish different network-relayed frequencies, and proceed in the previously described manner (example: 146.52/146.52 MHz into the network; 146.16 MHz out of the network. One or two fully microprocessor-controlled transceivers are required for this option.)

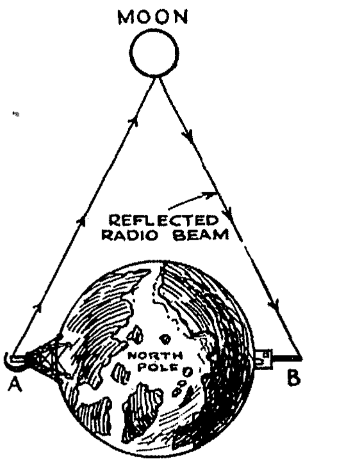
A full description of the network would, obviously, encompass numerous pages of discussion. I thus leave those operations open for your imagination and thoughts of expansion. The network outlined is a coarse system for future communications techniques. I hope this first basic step will inspire future developments.

ham radio

*Similar units for operation on 2.1 GHz will soon be available from Universal Communications, P.O. Box 339, Arlington, Texas 76010. The 2.1-GHz units furnish 100 milliwatts or 1 watt, as required. Cost of 10-GHz Gunnplexers are approximately $115 each; cost of 2.1-GHz units are approximately $170 each.

ham radio TECHNIQUES

Bill Orr W6SAI



This represents a suggested method of sending a radio wave to the moon and back; to determine by the reception of the reflected wave the permeability of the Heaviside layer. It was proposed in RADIO NEWS *for February, 1929, by H. Gernsback, the editor.*

fig. 1. Hugo Gernsback, the publisher of *Radio News* and many other technical magazines, suggested moon-reflected communications in 1929. It took thirty years for Amateurs to make the dream come true, although military and commercial moonbounce circuits were running soon after World War II.

This year marks the fifty-third anniversary of moonbounce (EME) communications! Happy Birthday, EME!

There are over five-hundred stations worldwide communicating via the earth-moon-earth link today. But the idea was the first proposed in 1929 by Hugo Gernsback, writing in the old *Radio News* magazine (**fig. 1**). Hugo had the right idea, but, like other geniuses, he was years ahead of his time.

more about antennas

Interested in unusual antennas? Here are some that should excite your curiosity.

The Snyder broadband dipole. One of the problems that confront hams operating on the lower frequency bands is the narrow passband of simple antennas close to the earth. Nowhere is this problem more troublesome than on the 80 and 160 meter bands. Both bands are relatively wide in terms of the center frequency and in both cases antennas for these bands are usually very close to the earth (less than a quarter-wavelength for a dipole, in many cases). I heard about the antenna developed and sold by Dick Snyder and my first impression was negative — drawings of the new antenna made it look very much like the discredited "coaxial dipole" which was exposed by Walt Maxwell, W2DU, in *QST* and *ham radio* some years ago.[1]

The temptation to try the new antenna was too great, however, so I ordered the 160-meter antenna to try out against my regular 160-meter dipole. My own 160-meter antenna was certainly poorly positioned. The center was only forty-five feet high and the ends drooped down to within ten feet of the ground, or less. In addition, the last fifty feet of each half of the dipole was doubled back to run around the house in an effort to keep a 250-foot-long antenna on a 150-foot-wide lot! As a result of all this antenna manipulation, the bandwidth of the dipole was very narrow, being less than 70 kHz at the 2.5-to-1 SWR points. Nevertheless, this is typical of

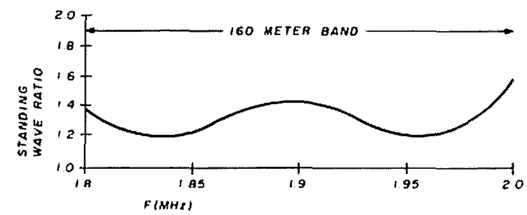


fig. 2. SWR curve for the Snyder 160-meter monoband. *Ham radio* produced a similar curve.

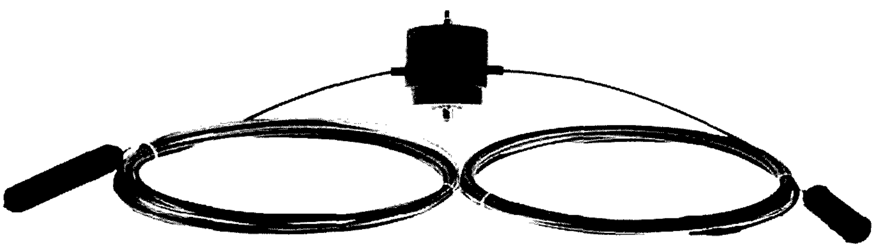


fig. 3. The Snyder dipole straight out of the shipping carton. Center unit holds ferrite impedance-matching transformer.

many ham installations squeezed on a small lot.

With a bit of finagling, the new Snyder antenna went up uneventfully in the same space as the old dipole. My only problem was that I didn't follow instructions exactly and undid both halves of the dipole from the packing straps at the same time. Being made of hard-drawn copper wire, the end sections went — spro-o-ng!! — like a coiled spring and I had antenna all over the place. It took a few minutes to get everything under control again, and this time, following the instructions, I got the new antenna up in the air and was ready for the test.

The Snyder engineer I'd spoken to said that the unique combination of the linear coaxial antenna sections plus the ferrite matching transformer was not really designed for such distorted antenna positioning. Even so, I was pleased to find that the antenna did provide better operating bandwidth over the 160-meter band than did my old dipole.

Since I couldn't do the test properly, I sent the antenna to the *ham radio* staff for further testing. Being out in the wilds of New Hampshire, they have plenty of space to properly install the antenna. They placed the apex at 60 feet and the ends at 35 feet. Their SWR graph, which agreed very closely with Synder's own, shows that the SWR never climbs above 1.5:1 from 1.8 to 2 MHz (see **fig. 2**). That is quite an accomplishment for any antenna.

This is an interesting antenna concept, and I have heard good reports from other hams who have used Snyder dipoles on the higher frequency bands (**fig. 3**). If you want more information, I suggest you write to Snyder Antenna Corp., 250 East 17th St., Suite 1, Costa Mesa, California 92627. And I'd be interested in hearing about your results with this interesting antenna design.

antenna for 160

One of the top-notch operators on 160 meters, as all "low-band" enthusiasts know, is Stew Perry, W1BB. He was working 160 DX when most of us were running around in three-cornered pants. Here's his suggestion for a good beginner's DX antenna for that band (**fig. 4**). It's an easy antenna to erect, tune-up, and load. Basically, it is about 5/8-wavelength long and works against a ground connection. The length is chosen so as to provide as high an input impedance as possible consistent with a simple matching system. Nothing could be simpler than this match — a single series-connected capacitor.

The antenna consists of a 40- to 50-foot vertical wire, top-loaded by a horizontal wire about 120 feet long. Overall wire length should run from 165 to 175 feet. The higher the vertical portion, the better the antenna will work.

As with the old Marconi antenna, the return ground system efficiency is important. W1BB uses several eight-foot ground rods, a nearby buried water-pipe system, and has several buried ground radial wires. For good luck, he's added several above-ground radial wires too. Stew says,

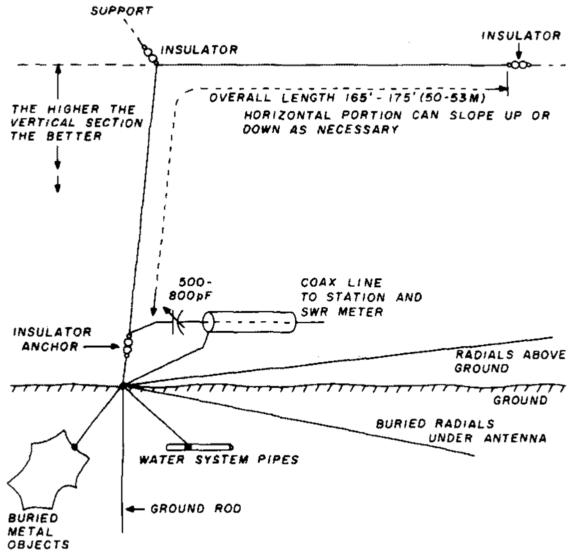


fig. 4. W1BB's suggestion for a good beginner's DX antenna for 160.

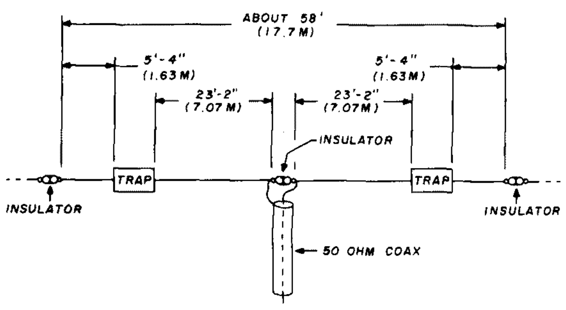


fig. 5. The 30-40 meter dual dipole. SWR is below 1.2 on 30-meter band and below 1.7 on 40-meter band. 40 meter resonance is about 7.13 MHz.

"The better the ground system, the better the results!" A low-voltage variable capacitor of about 700 pF is placed in a water-proof box at the base of the antenna. Simply tune the capacitor for lowest SWR at your pet operating frequency in the 160-meter band. The far-end of the wire may be then pruned for lowest SWR, if desired.

Stew says that with a good ground system, this antenna is almost as good as a quarter-wave vertical with an elaborate ground system. And best of all, it is not as noisy as a straight vertical for receiving. Stew tested the antenna in last winter's DX season, and many 160-meter operators will remember his outstanding signal.

a trap dipole for 30 and 40

If luck is with us, the 30-meter band will be open for U.S. Amateurs within two to three years. Shown in this section is a trap dipole designed for operation on 30 meters as well as 40 meters (**fig. 5**). Simplified traps, such as shown in N3GO's article in *ham radio*[2] are used. These simplified traps can be built in minutes and will work as well as the more complex, discrete-component designs that use separate inductors and capacitors. Trap design is shown in **fig. 6**. If built as shown, they need not be adjusted for frequency.

Overall length of the trapped antenna is about fifty-eight feet, making the design smaller than that for a full-size 40-meter dipole. This is very convenient for the ham with a small-size lot.

The trap is wound on a short section of 1¼-inch outside-diameter clear PVC water pipe. Lengths of RG-58A/U are used for the inductors. Exactly nine and five-eighths turns are required for trap resonance at 10.075 MHz. Each trap requires only about fifty-six inches of coaxial line, nuts and bolts for the termination points, and a length of PVC pipe. What could be cheaper?

When the traps are completed, they may be checked with a dip oscillator. Self-resonance between 9.9 MHz and 10.2 MHz is OK.

Resonance at 10.125 MHz (or thereabouts) is achieved by pruning the center sections of the antenna and resonance at 7.15 MHz is achieved by pruning the tip sections. SWR curves for the antenna described are shown in fig. 7.

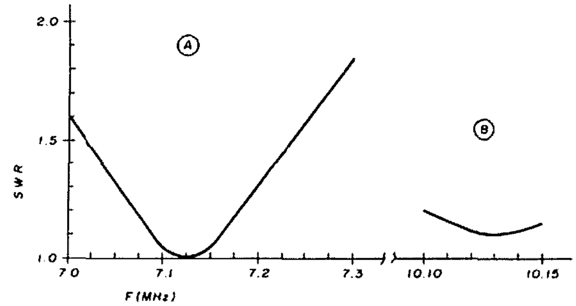


fig. 7. SWR plot of 30-40 meter dipole. A = 40-meter plot. B = 30-meter plot.

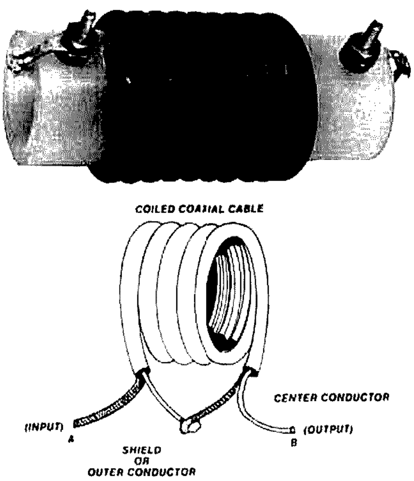


fig. 6. Single-element trap winding detail.

A word of caution. The traps should be protected from the weather. My original traps were exposed and I could notice that the SWR curves shifted when the traps became wet with rain. This was probably caused by an increase in the distributed capacitance between the turns of the trap coil caused by the film of water. The transmission line and ends of the trap windings should be protected from moisture, because water can be sucked into the line by capillary action along the braid wires of the shield.

My first try at sealing the traps was to use a tube of so-called RTV, bought at an auto supply store. This was a disaster — after a few days the metal hardware on the traps turned a nasty green color. I examined the tube of goop and noticed the words *contains acetic acid* among the small print on the back of the tube. So!

I then got a tube of the right stuff, *General Electric* RTV, and noted that no acetic acid was mentioned on the label. The traps were cleaned and the new RTV was slathered over the connections and the ends of the RG-58/U coaxial cable coil. That did the job.

As an alternative, *Dow-Corning* 3145 sealant can be used. It does not have the acid component in the mixture. (Warning! Dow Corning 732 Silastic Sealant, widely available, gives off an acid as it dries out. This, like the cheap so-called RTV, will damage metallic parts.) One learns something new every day.

references

1. Walter Maxwell, "The Broadband Double-Bazooka Antenna – How Broad Is It?" *QST*, September, 1976, page 29. Walt Maxwell, "A Revealing Analysis of the Coaxial Dipole Antenna," *ham radio*, August, 1976, page 46.
2. Gary E. O'Neil, "Trapping the Mysteries of Trapped Antennas," *ham radio*, August, 1981, page 46.

ham radio

HAM CALENDAR

August

SUNDAY | MON | TUES | WED | THUR | FRI | SATURDAY

1

45TH ANNUAL SOUTH HILLS BRASS POUNDERS & MODULATORS HAMFEST – Community College of Allegheny County, Pittsburgh. For more info contact WA3PBD – 1

NIAGARA PENINSULA ARC – Special Event Station celebrating the 100th anniversary of the Royal Canadian Henley Regatta – 1-8*

BIG THUNDER ARC HAMFEST – At Boone County Fairgrounds, Rt 76, Belvidere, IL. For more info. contact SASE to Jim Grimsby, 418 Beacon Dr., Belvidere, IL 61008 – 1

29TH ANNUAL SOUTHWESTERN MICHIGAN VHF FAMILY PICNIC – Sponsored by the Black River ARC at West Side County Park near Glen. Contact K8Z – 1

17TH ANNUAL HOCKLEY COUNTY ARC PICNIC AND HAMFEST Co-sponsored by the Northwest Texas Emergency Net to be held in the Levelland, Texas city park – 1

24TH ANNUAL FM PICNIC AND HAMFEST – Sponsored by the Steuben County Radio Amateurs at Crooked Lake, Angola, IN – 1

2

3

4

5

6

50TH ANNUAL W1MU AMATEUR RADIO CONVENTION – West Yellowstone Convention and Civic Center, W. Yellowstone. For more info contact K7ENE – 6-8

7

TRI-COUNTY ARC ANNUAL HAMFEST/PICNIC – Held at Los Angeles County Fairgrounds, Pomona, CA. For more info. contact TCARA Hamfest Chairman W6ELZ, POB 142, Pomona, CA 91769 – 7

EUROPEAN C.W CONTEST – 7-8

DARC WAE C.W. CONTEST – 7-8

A5 FSTV UHF CONTEST – 7-8

ARRL UHF CONTEST – 7-8

GREATER JACKSONVILLE HAMFEST ASSOCIATION'S 9TH ANNUAL HAMFEST & ARRL CONVENTION – Orange Park Kennel Club. For more info contact NX4G – 7-8

8

VALLEY OF THE MOON ARC 3RD ANNUAL "HAM" BREAKFAST & SWAPMEET – Sonoma Community Center, 276 East Napa St., Sonoma, CA. Contact VOMARC, 358 Patten St., Sonoma, CA 95476 – 8

MID-ATLANTIC ARC ANNUAL J.B.M. HAMFEST – Route 309 Drive In theater, Montgomeryville, PA. For more info contact Mid-Atlantic ARC, POB 352, Villanova, PA 19085 – 8

ST. CLOUD RADIO CLUB HAMFEST – Held at Sauk Rapids Municipal Park, Sauk Rapids, MN. For more info. contact Mike Lynch, 2115 1st St., St. Cloud, MN 56301 – 8

CENTRAL KENTUCKY ARRL HAMFEST – Sponsored by Bluegrass ARS at Scott County H.S., Longlick Road at US route 25, Georgetown. For more info contact K4DHN – 8

9

10

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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13

TEXAS VHF SOCIETY'S 1982 SUMMER MEETING – Nassau Bay Resort Motor Inn, Johnson Spacecraft Center, Houston. For more info contact Texas VHF FM Society, Summer Session, POB 73, Texas City, TX 77590 – 13-15

ALLIANCE ARC EXHIBITION – The Alliance (OH) ARC will exhibit emergency radio communications during Carnation week at Silver Park – 13-15

14

ENGLEWOOD ARA 23RD ANNUAL NEW JERSEY QSO PARTY – 14-16*

BURLINGTON ARC – *Annual Hamfest, Burlington, VT 05402* – 14-15

HAMFAIR 82 – Sponsored by the Radio Club of Tacoma at the Pacific Lutheran University campus. For more info: AD7S – 14-15

BERRY'S MOUNTAIN ARC DXPEDITION – 14*

15

IOWA 75 METER NET – Picnic and swapfest at River Valley Park, Ames, IA. For info, contact WB0JFF, Net Sec – 15

TIPPECANOE ARA'S 11TH ANNUAL HAMFEST – Tippecanoe Fairgrounds, Teal Rd. and 18th St., Lafayette, IN. For tickets and info, contact Lafayette Hamfest, Rt 1, Box 63, West Point, IN 47992 – 15

7TH ANNUAL NEW DELMARVA HAMFEST – Gloryland Park, Bear. For more info, contact Stephen Momot, K3HBP, 14 Balsam Rd., Wilmington, *DE 19804* – 15

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AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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19

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21

HURON COUNTY ARC – Celebrates 169th anniversary of the Battle of Lake Erie on South Bass Island in Lake Erie. For special QSL card after making contact, send QSL and SASE to ARS KF8O – 21-22

RAMAPO MOUNTAIN ARC, WA2SNA – 6th annual flea market held at Oakland American Legion Hall, 65 Oak St., Oakland, NJ. For more info, contact WO2AAI – 21

HUNTSVILLE HAMFEST – Held at Von Braun Civic Center, Huntsville, AL. Free Admission. For more info, contact Huntsville Hamfest, POB 4563, Huntsville, AL 35802 – 21-22

TIOGA COUNTY ARC 6TH ANNUAL HAMFEST – To be held at Island Park, just off US Rt. 15, Blossburg, PA. For more info, contact KC2AZ – 21

MARYSVILLE HAMFEST – Sponsored by Union County ARC at the Marysville Fairground. For more info, contact UCARC, 13613 US 36, Marysville, OH 43040 or call (513) 644-0468 – 21-22

SARTG RTTY CONTEST – 21-22

22

ST. CHARLES ARC HAMFEST '82 – To be held at Wentzville Community Club. For more info, contact SCARS Hamfest, c/o W0OGSY – 22

ILLINOIS STATE ARRL CONVENTION – Sponsored by Fox River Radio League at Kane County Fairgrounds, St. Charles, IL. For more info, contact KA9HQY or WD9GIG – 22

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24

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

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AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

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28

ALL ASIAN C.W. CONTEST – 28-29

29

4TH ANNUAL GCARC HAM/COMPFEST – Sponsored by the Gloucester County ARC at the Gloucester Community College, Tanyard Rd., Sewell, NJ. For more info, contact club at POB 370, Pitman, NJ 08017 – 29

LEBANON HAMFEST – Sponsored by Short Mountain Repeater Club held at Cedars of Lebanon State Park, US 231, Lebanon, TN. For more info, write Mary Alice Fanning, KA4GSB, 4936 Danby Dr., Nashville, TN 37211 – 29

1ST ANNUAL DXPEDITION OF KANSAS STATE UNIVERSITY ARC AND MANHATTAN AREA ARS – Held in Pott County. For certificate, SASE to W0QQQ, Electrical KSU, Manhattan, KS 66506 – 29

30

31

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

W1AW Schedule

April 25-October 24, 1982 — MTWThFSSn = Days of Week — Dy = Daily

W1AW code practice and bulletin transmissions are sent on the following schedule

EDT	Slow Code Practice	MWF 9 A.M., 7 P.M.; TThSSn 4 P.M., 10 P.M.
	Fast Code Practice	MWF 4 P.M., 10 P.M.; TTh 9 A.M.; TThSSn 7 P.M.
	CW Bulletins	Dy 5 P.M., 8 P.M., 11 P.M.; MTWThF 10 A.M.
	RTTY Bulletins	Dy 6 P.M., 9 P.M., 12 P.M.; MTWThF 11 A.M.
	Voice Bulletins	Dy 9:30 P.M., 12:30 A.M.
CDT	Slow Code Practice	MWF 8 A.M., 6 P.M.; TThSSn 3 P.M., 9 P.M.
	Fast Code Practice	MWF 3 P.M., 9 P.M.; TTh 8 A.M.; TThSSn 6 P.M.
	CW Bulletins	Dy 4 P.M., 7 P.M., 10 P.M.; MTWThF 9 A.M.
	RTTY Bulletins	Dy 5 P.M., 8 P.M., 11 P.M.; MTWThF 10 A.M.
	Voice Bulletins	Dy 8:30 P.M., 11:30 P.M.
PDT	Slow Code Practice	MWF 6 A.M., 4 P.M.; TThSSn 1 P.M., 7 P.M.
	Fast Code Practice	MWF 1 P.M., 7 P.M.; TTh 6 A.M.; TThSSn 4 P.M.
	CW Bulletins	Dy 2 P.M., 5 P.M., 8 P.M.; MTWThF 7 A.M.
	RTTY Bulletins	Dy 3 P.M., 6 P.M., 9 P.M.; MTWThF 8 A.M.
	Voice Bulletins	Dy 6:30 P.M., 9:30 P.M.

**SEE COMING EVENTS*

eight-channel memory scanner for the Sony ICF-2001

Modifications to increase the versatility of this general-coverage receiver

A low-cost modification to the Sony model ICF-2001 receiver allows sequential sampling and automatic acquisition of any eight active frequencies from 150 kHz to 30 MHz. This modification uses eight readily available ICs and adds a significant degree of automation to a variety of monitor applications without inhibiting any of the original receiver functions.

The ICF-2001 receiver provides some surprisingly professional state-of-the-art features. I had seen this receiver in numerous magazine ads for a year or so before deciding to consider it as a second or backup monitor receiver. The key pad frequency entry (without any bandswitching) and up-down incremental tuning took a little getting used to after years of using the R-390A and other vintage receivers. However, once I adapted, I discovered its outstanding frequency stability and tuning accuracy attributes, which are the product of phase-locked-loop (PLL) synthesizer design. Admittedly, this receiver's selectivity is no match for the R-390A, but other features such as small size, low power consumption, ease of operation and utility have given it a prominent position in my station. For those interested in the considerable number of signals outside the ham bands (for example, RTTY press, aeronautical and maritime communications), the general-coverage aspects of the ICF-2001 should have great appeal.

some uses

The ability to store six preset frequencies for instant pushbutton recall and the capability to scan continuously between two preset frequencies and automatically stop on active signals were of particular interest. Repeated use of the scan mode of operation in the receiver led to the design of the following modification, which has permitted continuous sequential scanning of the memory channels with automatic dwell capability on active channels. Although these search-dwell features are common in the popular VHF-UHF scanners, their use in high-frequency receivers is restricted primarily to expensive special-purpose equipment. Some of the uses I have found to be convenient in the modified receiver include the ability to determine unpredicted band openings without dedicated listening and to maintain a "quiet" speaker watch on several fixed-net frequencies for out-of-schedule activity, particularly emergency and rescue nets.

By Bill Farmer, W3CSW, 16920 Glen Oak Run, Rockville, Maryland 20855

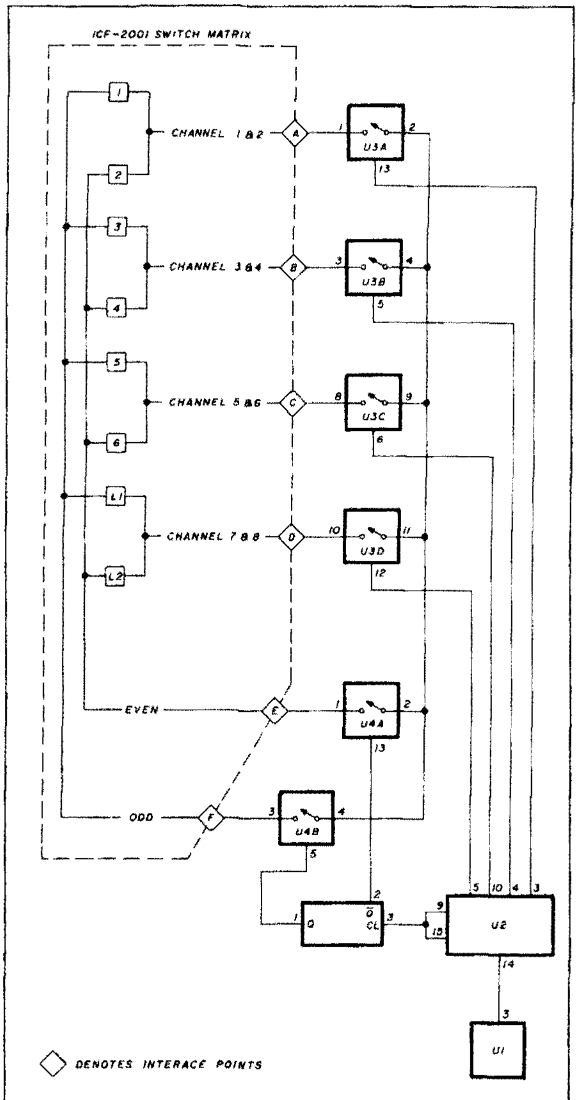


fig. 1. Simplified schematic of CMOS switching scheme, existing pushbutton switch matrix and interconnecting points.

about the circuit

For automatic sequencing of the pushbutton memory channels, a scheme of electronic switching connected in parallel with the existing memory channel and scan limit pushbuttons is used. As shown in **fig. 1**, the basic circuit uses CD4066 quad bilateral switches controlled by a CD4017 one-of-ten counter and a CD4013 dual D flip-flop. Timing pulses are generated by an XR-L555 low-power timer. Pulses generated by U1 cause U2 pins 3, 4, 10, 5, and 9 to alternately go high for one count each. This action sequentially pulses CMOS switches in U3, which are connected to one side of the ICF-2001 pushbutton switch matrix. As U2 pin 9 goes high, it resets the timing sequence and clocks U5, which alternately closes and opens CMOS switches in U4A or U4B. These switches are wired to the ODD and EVEN sides of the switch matrix. This cyclic operation causes odd-numbered memory channels 1-3-5-7 to be scanned (turned on and off in sequence), followed by even-numbered channels 2-4-6-8. Pushbuttons for channels 7 and 8 are actually the high and low search limit switches labeled L1 and L2 on the ICF-2001. This switching scheme is relatively straightforward and has been gleaned from previously published articles and application notes featuring the CD4066 and CD4017 ICs.[1,2,3]

additional circuits

There are a number of additional supporting circuits that must be incorporated if this automatic scanning feature is to serve a useful purpose. These

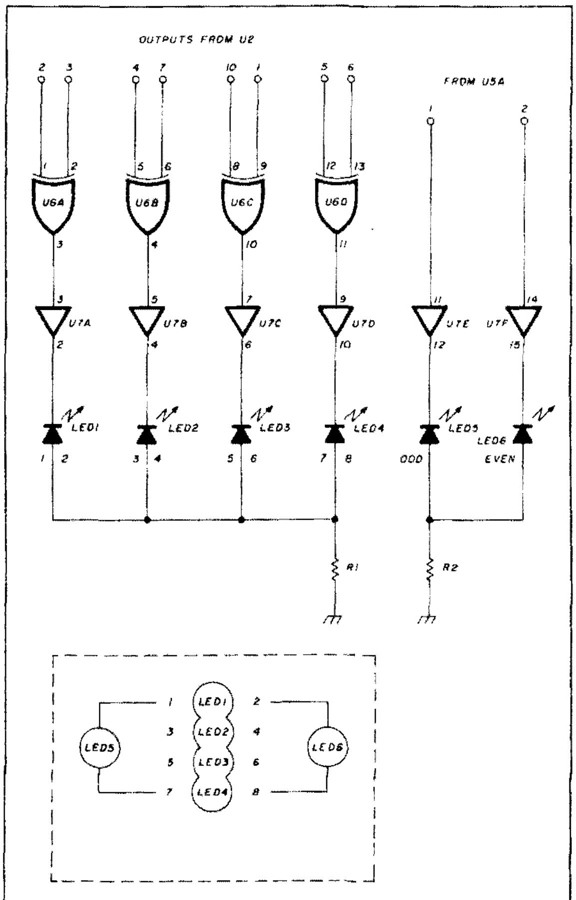


fig. 2. Channel-indicating circuit composed of LEDs (A), to show which channel is active or is being scanned. The front panel layout of LED1 through LED6 is shown in (B).

circuits will (a) provide a visual indication of which memory channel is being scanned or becomes active, (b) provide a means to automatically stop scanning when a signal occupies a memory channel, (c) cause the scan feature to resume search when signal activity ceases, (d) mute the receiver audio during scan (if desired), and (e) allow normal receiver pushbutton operation when not using the memory scan mode. These circuits make use of only three additional ICs and the unused portions of U4 and U5 plus a general-purpose NPN transistor and reed relay. **Fig. 2** depicts the use of U6 (quad exclusive-OR gate) and U7 (hex buffer), which drive six LEDs to provide visual indication of scanned or active channels. Sequencing for these ICs and LEDs is provided by the controlled sequential outputs of U2 for the four numbered LEDs; and, from U5A, Q and $\overline{Q}$ outputs for the ODD and EVEN LEDs. Resistors R1 and R2 provide current limiting for the LEDs. While scanning, the ODD and EVEN LEDs will alternately light, while the numbered LEDs will indicate which memory channel switch closures are occurring.

pause or dwell function

This portion of the circuit makes use of a section of the existing receiver circuit that automatically stops the original L1 and L2 search functions mentioned earlier (continuous search between two preset frequencies). An examination of the ICF-2001 schematic and a lot of trial and error probing revealed a point in the receiver that latched high (about +3 volts) during received-signal conditions and remained low during "no-signal" conditions. These levels are sufficient to trigger a D flip-flop in U5 and control operation of one of the leftover CMOS switches in U4.

Fig. 3 illustrates a simplified circuit that uses this "signal presence" point, G, to both automatically stop the memory scan and start delay time-out clock U8. This circuit allows the automatic-scan cycle to resume following a four- to six-second delay after a received signal goes off the air. Additionally, this part of the modification will allow muting the receiver audio during memory scan operation. During a scan, U5B provides the primary operating voltage ($+V_{CC}$) to U1, the scanner clock, through the Q output of U5B.

If a signal is detected in the memory channel being scanned, point G will swing to +3 volts. This causes U5B to reset, which removes power from U1. The delay time-out clock, U8, is powered up through U5B's $\overline{Q}$ output, turning on Q1 and RY1, whose normally open contacts are in series with the ICF-2001 speaker voice coil. Notice also that with a received signal present and +3 volts at point G, which turns on CMOS switch U4C, the time-out-clock charging capacitor C1 is shorted. This prevents or delays the

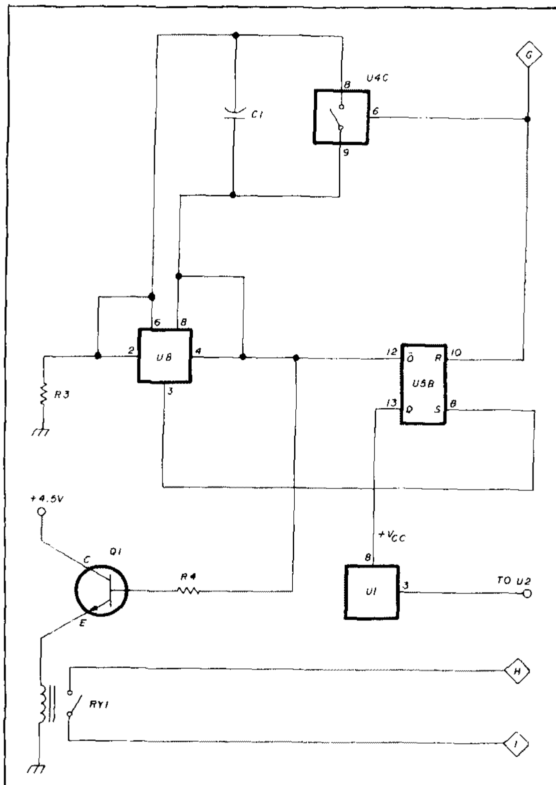


fig. 3. Simplified circuit that provides automatic scan stop and re-start functions as well as audio squelch and delay timeout provisions.

U8 and R3C1 timing function until a "no signal" condition causes point G to go low. The stop-scan condition will prevail as long as a signal is present and +3 volts are maintained. The RC time constant for U8 was empirically derived to account for QSB and other random "no signal" conditions that are observed in high-frequency CW and SSB communications. Once the signal goes off the air, or fades for longer than 4 to 6 seconds, U8 times out, which results in a high at pin 3 providing a set condition for U5B and resumption of scan with muted audio.

additional circuit functions

The remaining add-on features are best described using **fig.** 4, the overall schematic. (A parts list is provided in **table 1**.) Notice that switch S1 (a 3PDT toggle switch) performs three separate functions. S1A enables or inhibits U2 to permit manual stop-start of memory channel scanning. S1B opens the receiver switch matrix ODD-EVEN common connection so that in the MANUAL (non-scan) mode, no switch connections are closed that would preclude normal pushbutton operation of the receiver. Finally, S1C is

inserted in parallel with RY1's contacts so that normal unsquelched audio is always available in the MANUAL mode.

Three other switches appear in **fig. 4** that perform the following optional, but recommended functions. When S2 is in the eight-channel position, all eight memory channels are scanned as described earlier. However, when switched to the four-channel position, S2 disables U5A flip-flop action, causing repetitive scanning of only four ODD or four EVEN channels. By manually toggling S2 while in the MANUAL, or non-scanning, mode, the ODD or EVEN LED will indicate whether channels 1-3-5-7 or 2-4-6-8 will be scanned when S2 is finally placed in the four-channel position. This simple option permits segregating ham- and non-ham-band frequencies of interest into

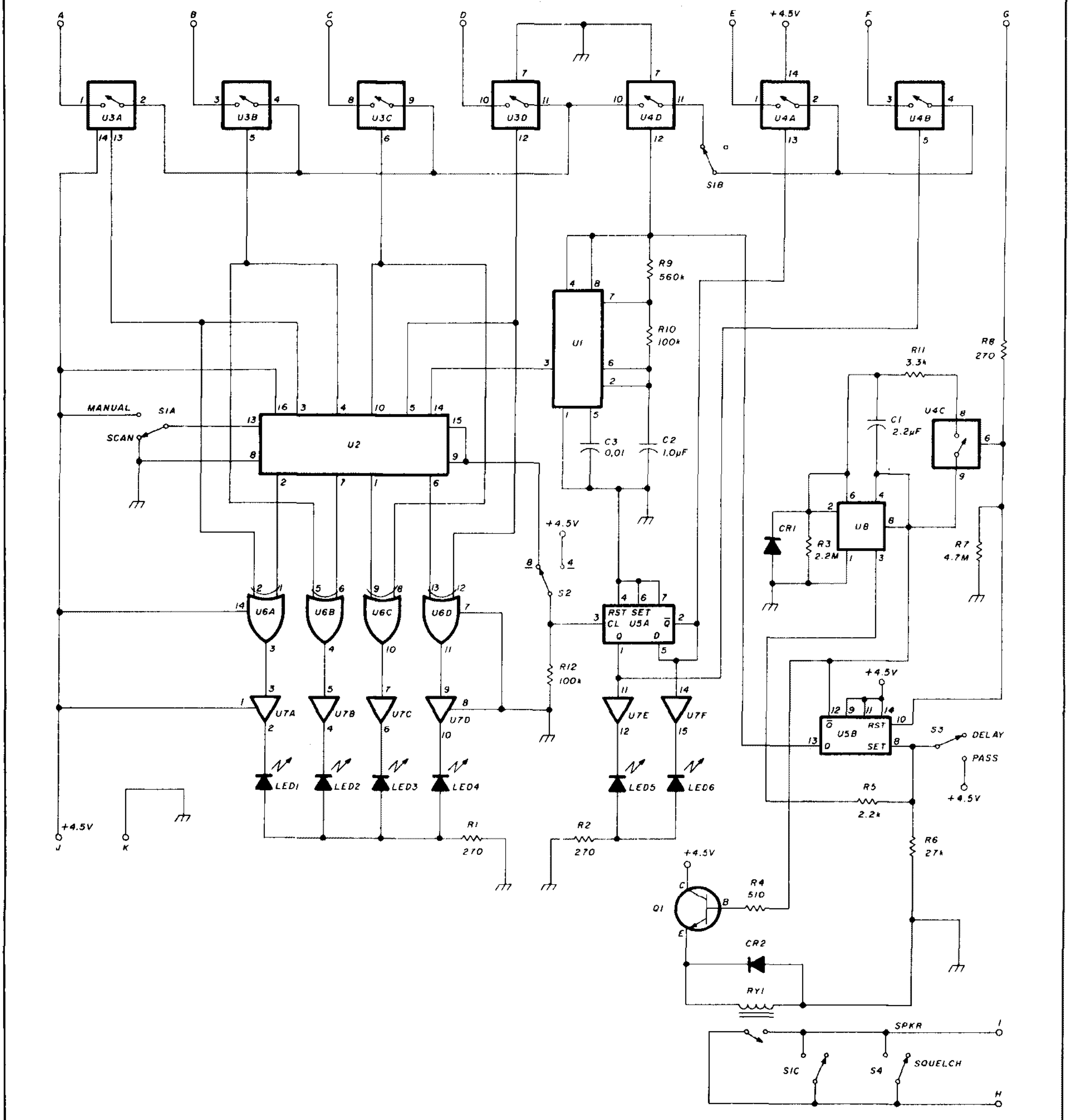


fig. 4. Overall schematic diagram of memory scanner modification.

table 1. ICF-2001 scanner modification parts list.

symbol	description
C1	2.2 μF 35V tantalum
C2	1.0 μF 35V tantalum
C3	0.01 μF 50V disc ceramic
CR1, 2	1N914 diode
LED1-6	light-emitting diodes, nominal 10 mA, Jameco XC526R
Q1	2N3904 NPN
R1	270 ohm ¼ watt
R2	270 ohm ¼ watt
R3	2.2 megohm ¼ watt
R4	510 ohm ¼ watt
R5	2.2 kilohm ¼ watt
R6	27 kilohm ¼ watt
R7	4.7 megohm ¼ watt
R8	270 ohm ¼ watt
R9	560 kilohm ¼ watt
R10	100 kilohm ¼ watt
R11	3.3 kilohm ¼ watt
R12	100 kilohm ¼ watt
RY1	5 Vdc SPDT mini relay, Jameco HA1-5
S1	3PDT toggle switch, Jameco 7301P3
S2-4	SPDT toggle switch, Jameco JMT-123
U1	XR-L555
U2	CD4017
U3	CD4066
U4	CD4066
U5	CD4013
U6	CD4070
U7	CD4050
U8	XR-L555

separate groups of four channels for selective monitoring.

Switch S3 is added to the SET pin of U5B to momentarily break audio squelch as signals are acquired during scan without stopping the scan sequence. The switch is labeled DELAY and PASS to denote normal scan delay with the four to six second timeout as previously described, or to pass up active channels after briefly listening to the active channel's audio. I found this mode useful when monitoring specific channels for expected activity that were already in use by other stations. Momentary aural samples of a channel allow continuous uninterrupted scanning action along with enough aural information to know when a channel is no longer in use.

The final switch, S4, which is labeled SPKR/SQUELCH is a switch in parallel with RY1 contacts to allow normal audio output while in the scan mode. The repetitive *ker-chunk, ker-chunk* as the receiver steps through empty channels is not normally desired. However, this provision is included to permit aural recognition of weak signals that are unable to develop sufficient AGC action in the receiver to cause automatic scan stop.

Incidentally, the ICF-2001 is no slouch in the sensitivity department considering its fixed 6-kHz i-f bandwidth. Comparative tests showed that signals in the quarter microvolt region are aurally discernible, and that typically signal levels of about S6 to S8 were sufficient for automatic signal acquisition by the modified receiver. A separate project to improve the selectivity of the ICF-2001 is currently on the drawing board.

interface connections

A total of eleven interface connections must be made to the ICF-2001. These connections are indicated in the figures as A through K and are shown pictorially in **figs. 5** and **6**. Dense packaging within the radio will demand careful attention to detail while making these connections. I found that mounting a small prewired multipin connector through the rear of the radio near the D-cell battery compartment gave good internal access and allowed unencumbered use of the set with the modification unplugged. The use of small color-coded ribbon cable is recommended for all interior connections. There's no room here for your 500 watt plumber's iron, so muster the lowest wattage pencil iron and smallest tip you can find. Remember, you are working with CMOS devices so ensure all handling and soldering is done in a static-free environment.

Begin by removing all batteries and the six Phillips-head retaining screws that hold the front and back sections of the radio together. Ensure the external antenna terminals are screwed in tight, then carefully separate the two halves of the radio, resting the heaviest half (speaker, battery compartments and main PC board) on the working surface, while propping the front-panel half up at about a 90 degree angle. Next remove the single Phillips-head screw securing the speaker, and lift the speaker up, out and to the left of your work (refer to **fig. 5**).

Carefully unsolder and remove the two-color (red/white) striped lead from the speaker *voice-coil* terminal. This lead represents interface point H and

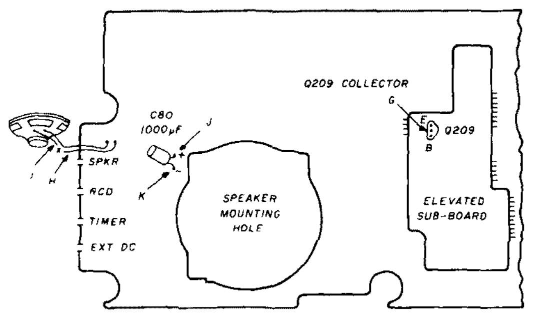


fig. 5. Pictorial of receiver interconnecting points G through K located on the main receiver PC board.

the now vacated speaker terminal interface point I. The solid-color (white) speaker lead is the speaker ground connection and is left as is. Next, isolate the 1000-μF electrolytic capacitor (C80), which is mounted on the main receiver PC board between the speaker mounting hole and the external SPKR/PHONE jack. The positive and negative terminals on this capacitor form interface points J and K respectively, which will provide about 4.5 volts dc power for the modification circuit. Just to the right of the speaker mounting hole, an elevated PC sub-board with many ribbon-wire connections will be found. This raised sub-board contains Q209 in the upper left corner. The base, collector, and emitter leads of Q209 are outlined and marked on the board. The center pin and lead (collector) of Q209 is interconnect point G.

The next six connections will be made to PC boards located beneath the front-panel pushbutton. To locate these connection points, first remove the Mylar foil shields that cover these PC boards. Referring to **fig. 6**, interconnect point D will be found on the lower left corner of the frequency-entry key pad, and the last five connecting points will be found on the left edge of the memory channel pushbutton PC board. These last five connections are made on the solder eyelets, which are vertically oriented and contain white, blue, yellow, red, and brown wires that interconnect the two boards. This concludes the work within the receiver. Ensure good lead dress to allow proper closure of the set. Additionally, mark the multipin connector terminals that correspond to audio leads H and I. These two terminals must now be shorted together for normal receiver operation without the scanner mod attached.

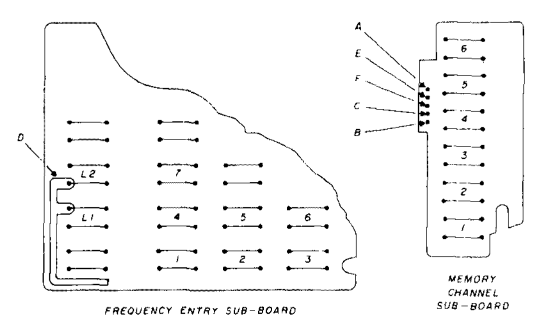


fig. 6. Pictorial of receiver interconnecting points A through F located beneath the frequency entry and memory channel pushbutton switches.

packaging and construction

Due to the "cigar-box" shape of the ICF-2001, I chose to mount it and the scanner mod on a 7-inch (17.5 cm) rack panel, which conforms to the rack-mount layout of my station. However, other arrangements such as mounting the scanner mod in a small sloping panel enclosure for desktop operation could be used. The scanner mod can be easily packaged within an area of about 3 × 4 × 1-inches (7.5 × 10 × 2.5 cm) using IC sockets and standard perf board with conventional point-to-point or wire-wrap connections. There are no critical lead length or layout precautions to observe. However, upon completion of the project and before connecting it to the receiver, some preliminary checks should be made:

1. Power up the scanner mod using a 4.5- to 5-volt dc source to ensure that manual start-stop of the timing and LEDs is occurring.

2. Check interface points A through G with the scanner mod powered up to ensure that less than about 0.6 volt dc to ground appears at these points. A high on any one of these points indicates a wiring error, which must be corrected before connecting the mod to the receiver.

3. Check the total current consumption of the mod, which should be on the order of 7 mA. This additional demand on the receiver is easily accommodated along with the nominal 150 to 200 mA requirements of the receiver from the external power supply furnished with the ICF-2001, which is rated at 4.5 volts dc at 600 mA.

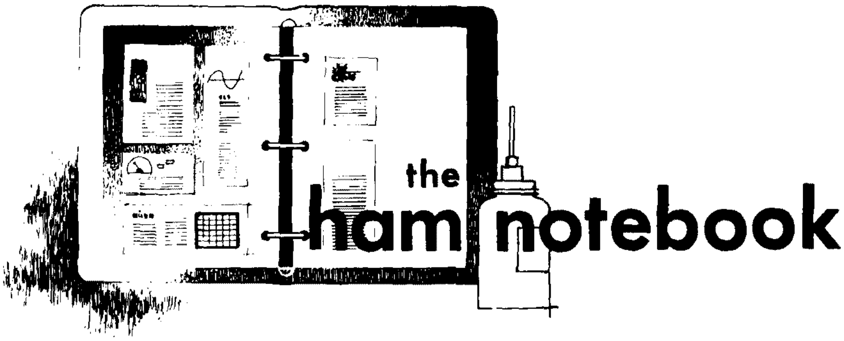
a final word

I've had this scanner modification in almost continuous use since August, 1981, without a hitch. While the modifications described in this article are directed toward the Sony model ICF-2001, the same techniques could apply to other digital receivers such as the Panasonic RF-6300 boasting twelve pushbutton memory channels. The modest cost of the ICF-2001 (under $300) and its increased utility after modification provide a new dimension in high-frequency monitoring, which has heretofore not been within the means of the average Amateur. I'd be pleased to correspond with anyone considering use of this modification and would appreciate any ideas on other applications or modifications contemplated for the ICF-2001. I'd be most grateful for a self-addressed, stamped envelope with all correspondence.

references

1. Forrest M. Mimms, "A Programmable Function Generator," *Popular Electronics*, January, 1982.
2. Howard M. Berlin, *555 Timer Applications Sourcebook*, first edition, second printing, 1979.
3. Don Lancaster, *CMOS Cookbook*, first edition, second printing, 1977.

ham radio



R-1000 mod

Owners of the Kenwood R-1000 receiver have probably wondered how they *can* listen to signals in the 200-500 kHz band without getting QRM from broadcast station images. I had this problem and solved it by installing a lowpass filter in series with the antenna.

I had at first anticipated that the 30-foot-long antenna wire I was using could be tuned with an antenna tuner. But that did not work because the R-1000 low-frequency-antenna input is 1000 ohms and would still pick up these images. This high input impedance is hard to work with, but a lowpass filter does the job!

construction

I built my filter in a small metal box using 0-400 pF variable BDC-type capacitors — not compression-type (see **fig. 1**). Other than the capacitors and a box, all I needed was an inductance. The J.W. Miller #2007 Loop Stik, which tunes 540-1650 kHz with an inductance of 150-1000 μH and a Q of 220 at 790 kHz, works perfectly. The slug was adjusted far enough into the core so that the capacitors would tune. Two feed-through insulators were used on the can for input and output. The unit should be shielded to prevent the BDC signals from bypassing the filter.

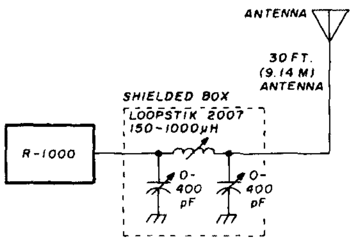


fig. 1. Lowpass filter for the R-1000.

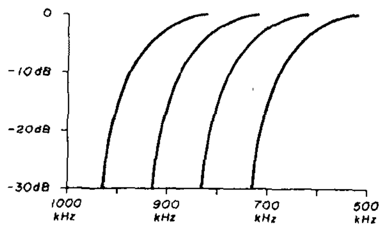


fig. 2. As the two variable capacitors are increased in value, the cut-off point of the filter goes lower in frequency and it attenuates the broadcast signals, which come in as an image on the receiver. Copying a signal on 475 kHz, you can only approach so close to 500 kHz and still have the 475-kHz signal. It does, however, eliminate or attenuate signals from 600 kHz to 1000 kHz well enough to make the 200-500 kHz band on the R-1000 useful. Instead of dozens of images there may be only several from local BDC stations.

adjustment

I adjusted my filter by tuning in a ship broadcast on CW at 475 kHz with both capacitors all of the way out, and an interfering BDC station coming in. Then gradually I increased the capacitance until the BDC station disappeared and all that was left was the ship broadcast station. See **fig. 2**.

This is the only device I have been able to find that makes this band and the 180-kHz non-license band usable.

Ed Marriner, W6XM

improved keying for the HW-8

My Heath HW-8 exhibited an excessively long rf output decay time. This resulted in choppy sounding CW at the higher keying speeds. Above about 25 WPM the output became a steady carrier even though the sidetone sounded good.

The problem was traced to the *break-in* delay *circuit* (**fig. 1**). Capacitor C92 was discharging through Q12 causing keying transistor Q11 to remain in conduction for over 100 milliseconds after the key was released. The solution was to reconfigure Q12 to function as an ordinary diode. When the key is up, Q12 is reverse biased, effectively disconnecting C92 from the keying circuit.

To make the modification, simply remove resistors R66 and R67 (both 4700 ohms). Then solder a jumper wire between the base and collector of Q12. This modification had no noticeable effect on the break-in delay circuit or the setting of the delay control.

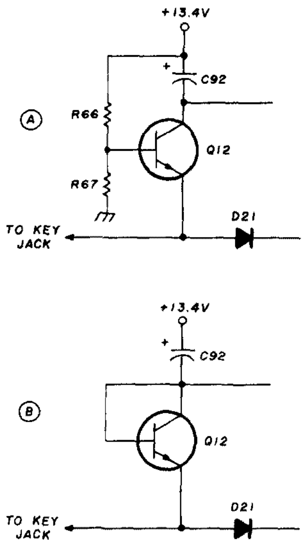


fig. 1. Original break-in delay circuit of the Heath HW-8, A. The improved circuit, B, eliminates choppy-sounding CW at higher keying speeds.

Robert W. Lewis, W3HVK

(Comments continued from page 8)
time until the same resolution is applied to 220 and 440? Probably the only reason these are not in danger now is that the pertinent CATV channels are not nearly so widely in use — but they will be as the CATV operators expand the number of channels they distribute.

The entire problem with respect to Amateurs can be resolved in either of two ways: (1) Take away virtually all the Amateur VHF-UHF bands, or (2) Deactivate three CATV channels out of the one hundred or so authorized. The third alternative, eliminating leakage points is simply not practicable. The systems are too complex, and subject to too many uncontrollable factors.

There is at least one thing Amateurs can do: present the facts to their local city council. CATV operators are franchised by the local community (not by the FCC), and Amateurs can often get a sympathetic ear at the local level — especially if their contributions to the community during emergencies and in other public service endeavors are pointed out. The cities would probably be willing to tell the CATV franchise to avoid using one (or at most, three) channels if that was all it took to preserve Amateur Radio in the community.

Frank Bates, AA6C
Santa Clara, California

the Zepp

Dear HR:

The excellent article by WØWL on the 40 and 80 meter center-fed Zepp antenna doesn't tell all. With proper antenna-tuning network, this antenna is an excellent all-band antenna. Also, by reducing the flat top length to 68 feet and using 66-foot feeders, you'll find that it will do a fine job on 80 through 10 meters. The 33 feet above ground is fine. After putting up this antenna in Florida I took down my three-element beam.

C.R. Sellwood, W2RHQ
Liverpool, New York

CRT character enhancer

A way of making your CRT readout even more readable

The purpose of **this article** is to give you clearer and easier-to-read video on your CRT display. Understanding why there is a problem with clarity on CRT screens requires that you first understand a few basic facts about TV and video-monitor CRT displays.

the *problem*

No TV or video monitor is really capable of producing the picture that you see on your CRT screen. Scanning devices make you think you see a picture by faking your eye into believing there is a whole picture there. In fact, there is only one dot at a time being produced by the electron beam as it strikes and excites the phosphor on the CRT screen. As time passes, the beam scans from left to right and top to bottom, painting an apparent picture on the screen. It is the persistence of the phosphor — that is, its ability to store or stay lit — that results in the picture you see on the screen. Therein lies the essence of television, and therein also lies a problem when you try to get nice, sharp characters, numbers, or symbols on the screen.

The scan rate from left to right (63.5 μs) is much faster than the line-by-line sweep from top to bottom (16.66 ms). This results in the dots in any given horizontal line tending to "slur," or run into one another. Without a sharply defined space between them, the dots begin to look like a line even though you don't really want them to. Even if a full-TV-type interlace system is used there is still some defined black space vertically between lines. And normally, on monitors and video displays, this is even more pronounced because interlace is not used. Therefore a full line of black exists between the lines vertically.

the ideal, and the difficulty of reaching it

Look at fig. 1. **Fig. 1A** shows a perfect string of horizontal dots, all clean and round. It would be nice if any monitor did this, even under ideal conditions, but they usually do not. **Fig. 1B** shows what in fact the eye will see when objects such as dots are identi-

By David J. Brown, W9CGI, RR 5, Box 39, Noblesville, Indiana 46060

cal, or even very similar in shape; or when they are very small, or your viewing distance relative to the dot size is large; or when the dots are very close together or slightly touching. **Fig. 1C** shows the visual results of finite turn-on and turn-off times in video amplifiers, display tube, and gun. Even the phosphor has an inherent delay time. **Fig. 1D** shows how the eye's lack of definition (**1B**) plus the CRT timing effects (**1C**) combine to cause an apparent line to form where a horizontal dot string should be showing.

How this affects your eye's ability to read a string of characters, or even define a single character, becomes clear when you look at the sample character string in **fig. 2A**. I have exaggerated the effect a little by simply showing the horizontal dot string as solid lines, just the way they really appear on your CRT screen. By sharp contrast, note the ideal appearance of the same character string in **fig. 2B**.

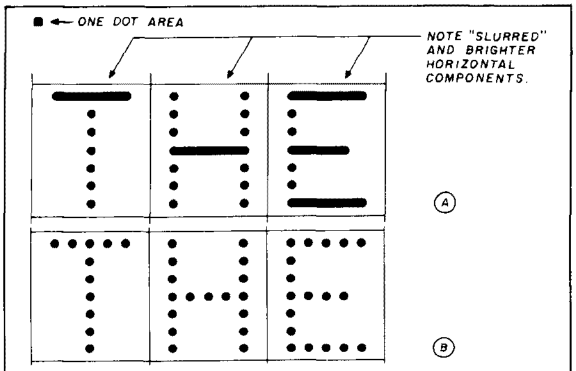


fig. 2A In *A*, the unmodified CRT screen, horizontal rows of dots run together to produce characters of unequal brightness. In *B*, modified characters of equal brightness result in far less eye strain and fatigue.

the eyes have it

The eye is a compensating light receptor, and as such will "open up" and "close down" (in various areas of the field of vision simultaneously) to respond to the different light intensities of **fig. 2A**. By contrast, the dot string in **fig. 2B** causes only minor fluctuations in light intensity — and far less eye fatigue. An additional benefit is that errors in reading are also reduced. Characters of even density, or "weight" as it is called in drafting, are much easier to read. Most people can read them quickly and accurately, because the eye has less work to do.

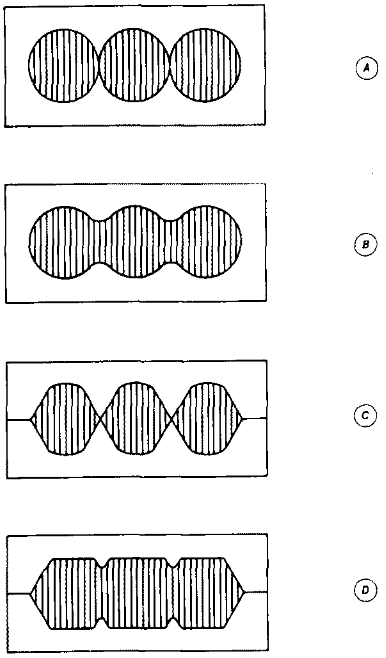


fig. 1. What you see on your CRT screen: *A*, a perfect string of dots as they might be seen under ideal conditions; *B*, the apparent running together of dots caused by lack of definition in the human eye; *C*, the effects of turn-on and turn-off times in the video amplifiers, display tube, gun, and even in the phosphor itself; *D*, the combined effects of *B* and *C*.

Now that you see the problem, try to imagine how difficult this printed page would be to read if all the horizontal components of each character were bolder or blacker than the vertical components. IT IS DIFFICULT TO DO THAT IN PRINTING, SO I HAVE ASKED THE MAGAZINE TO PRINT THIS SENTENCE IN ALL UPPER-CASE LETTERS. This should allow you to at least visualize the problem I am referring to, because upper-case letters have a lot more horizontal components. Most hobby computers use all upper-case letters in their visual displays, so the problem becomes magnified.

Take another look at **fig. 1D**. We could eliminate this dot-pairing effect if we could just drop a hole, or "off" time, into that slurred line between the dots. In **fig. 3A** you can see the effect this has. It separates the dots. Ignoring the weird appearance of the dots for a moment, I think you will at least agree that they no longer look like a line. The shape of these dots is, I admit, less than perfect.

The turn-off delay of any switch I might use to shoot the horizontal line of dots full of holes also has the effect of smoothing out — sloping the edge of — the dot. See **fig. 3B**. Now we are getting back to a dot that at least looks like a dot. As I would in CW, I am simply wave forming, shaping, and filtering. In CW it is done to avoid the harsh on/off transitions that cause chirps and clicks. This is the same idea ex-

actly, but here it is done for the *benefit of the eye* rather than the ear. First, the hole is inserted to sharply define the space between two legitimate dots. Then, the effect of switch times and various elements in the video chain rounds off the harsh edges, much like CW filtering.

Since every computer is different, I can't tell you where to begin component by component. I can, however, give *you a description of the* stages to look for, the facts you need to know or find out, and the reason my modifications will cure the problem.

Find the video sector of your machine and try to determine the polarity and amplitude (TTL, and so forth) at as many places within that area as you can. Since many machines use TTL logic, my examples will be in TTL. In your own case, just make sure the two signals you will be working with are logic-and level-compatible with each other as well as the device you will end up combining them in.

My machine is totally homebrew, but as an example, in my final video stages I had run the video through a noninverting gate (7409) just to buffer it and give me an uncommitted (non-totem-pole) output to interface to the TTL stages that follow. That involved taking the two inputs together, so that a high at the input creates a high at the output. A high, in my case, represents video enabled — a dot. Further, each dot in my system has a period equal to a full cycle of the resident clock frequency.

I wanted to use the resident clock frequency for several housekeeping chores in the computer, so I had allowed earlier for six buffered clock outputs. These are all square waves at the clock frequency, so they are high for one *half the* period; low *for the* other half. You will have to look for the same type of signal in your machine: half-cycle on (high), half-cycle off (low), for the period of one dot in your character display. Careful! This will not necessarily be the clock frequency in some machines. It is in mine, because I chose it to be so. What you want is a clocking frequency that can be used as a gate control to turn off half a dot.

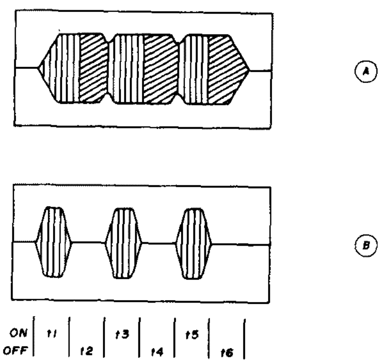


fig. 3. ***A*, Horizontal dots with "holes" inserted. In *B*, the dots have been rounded somewhat by filtering and the delay inherent in switching.**

Except for performing the actual surgery, you are essentially through once you've located the following: the clock frequency or appropriate gate signal stage, which you may have to buffer; the video at the same type level, which might take a few additions; and a stage to combine them in (you will probably have to add this in a commercial computer, but look around for unused gates). There are a few pitfalls to avoid here, so your first try may not be perfect. Let's go over them one at a time.

1. Careful surgery and soldering are crucial!

2. Careful wire routing is mandatory.

   (a) Keep video leads away from any of the rather large pulses found in the deflection circuits of the monitor/CRT display. If your computer is not in the same box as the monitor/CRT, or is hidden under the keyboard, as in the TRS-80, so much the better.

   (b) Stay away from the high-voltage lead on the CRT with everything, including your fingers!

   (c) Clock-signal wiring must be routed so that nothing gets into it, to preserve the computer integrity. It must also be routed to keep it out of everything else, except the gate to which you are routing it.

   (d) Don't use a vacant gate, no matter how tempting, if it involves making long runs to get there and back. An inexpensive 7409 and socket added somewhere in the video territory is by far a better way to go.

   (e) Make the clock-signal lead the longer one, and locate the gate right in the video region, if you have the option of doing it that way or the other way around.

3. Be careful of mixed logics, levels, voltages, polarity, and above all, isolation methods.

   (a) Isolation should not be a problem, as you should be working all inside the computer. I caution you only because a lot of monitor/CRT displays run "hot" chassis systems. Be careful.

   (b) Logic and levels *will* probably *work out all* right, but beware of a few mixed-mode TTL/MOS systems.

   (c) Voltages for the added gating device, if needed, should be easy to find, as most computer

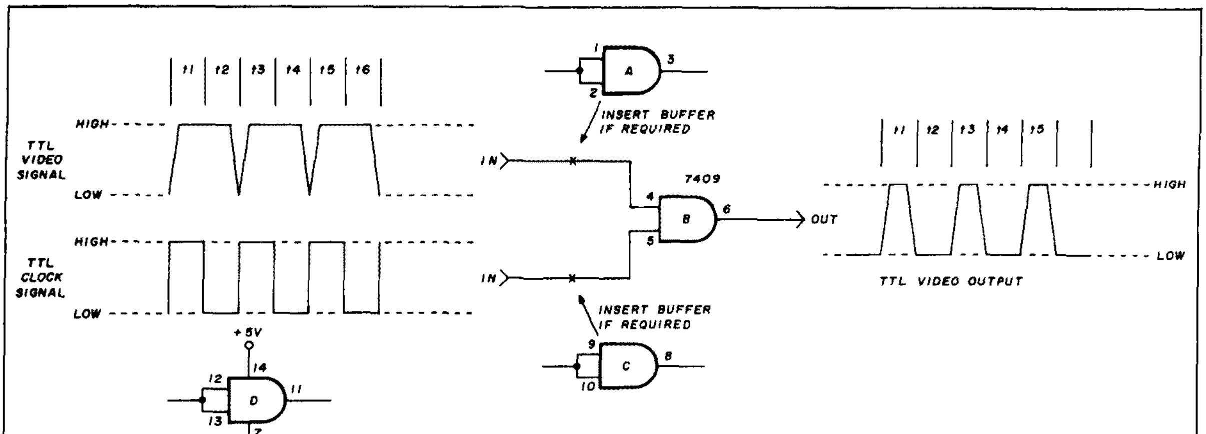


fig. 4. Gating and timing.

manufacturers wisely use oversize buses or copper pads on the + voltage and ground lines. If you must stand up the new gate, put a small 30 to 50 volt ceramic capacitor of about 0.1 μF from + V to ground right at the added socket's + V and ground pins. This is a precaution against trash pick-up or generation.

(**d**) That leaves polarity, and I mention it only to keep you from doing what I did while modifying a friend's computer. I inadvertently got one or two signals inverted trying to use existing gates. It was easily cured but most embarrassing. Use a bit of forethought and add little (⊓) (⊔) symbols to your schematics if they are not already there, to show signal polarity at various points.

4. RFI?

(**a**) All computers generate radio-frequency interference. But nearly all of them nicely confine it inside the computer.

(**b**) If you have one of the out-in-the-open board-type computers, your own keyboard, or — in short — a modular system, you may want to run an RFI check before and after. A shortwave radio and small antenna, tuned to the clock rate frequency you used, will work fine. You might even want to check your commercial, closed-up system just for your own protection against TVI complaints.

summary

I hope this simple two-signal, one-gate approach will convince you how easy this conversion is to accomplish. I have included **fig. 4** to get you off on the right track.

Another change you will notice will be in the brightness, or drive of the display. You can compensate for this by simply turning up the drive or contrast control. Don't worry about anything you may have heard about some people burning up CRTs by using high drive settings for TV games. This is not the same thing at all. With all computer characters, the white (on) to black (off) ratio, or duty cycle, is very low, and your turning up the drive on your new half-dot system is really going to give you a *lower* duty cycle than you had before. Each dot is now only approximately 50 percent of what it was. With all the dots now looking more or less the same, turning up drive in the new system will brighten all of the dots smoothly and evenly.

Set up the brightness and contrast/drive portion of your controls just as I hope you have been doing all along for best picture: Turn brightness up until you see the rectangle in grey that forms the visual page the characters will appear on. Then turn the brightness down until the grey area just turns black like the surroundings. With a few characters typed in, turn up the contrast (drive) control until the characters are pleasing to your eyes and bright enough to be read in the surroundings in which you are working. In some monitors, there is interaction between brightness and contrast, so be patient and go back and forth; the added time is worth it if you are going to be working at your computer any length of time. Also, if you have a choice between a brighter screen or a darker room, darken the room for less eye strain. If you are copying from a written page, tilt it up as a typist does, and direct a small lamp at the page. Keep the difference in lighting levels between the page and screen as small as possible. This, too, will make for a lot less eye strain. Home computing should be fun, and the easy-on-the-eyes format my system will give you is well worth the effort of installing it.

ham radio

Coming Events

ACTIVITIES

"Places to go..."

ALABAMA: The Huntsville Hamfest, Saturday and Sunday, August 21 and 22, Von Braun Civic Center, Huntsville. Free admission. Prizes, exhibits, forums, air-conditioned flea market, non-ham activities. Family tours of the Alabama Space & Rocket Center available. Limited camp sites w/hookups available. Flea market tables $4/day. Talk in on 3.965 and 34/94. For information: Huntsville Hamfest, PO Box 4563, Huntsville, AL 35802.

CALIFORNIA: The Valley of the Moon Amateur Radio Club's third annual "Ham" breakfast and Swapmeet Sunday, August 8, 9 AM to 4 PM, Sonoma Community Center, 276 East Napa Street, Sonoma. Breakfast features sausage, eggs, pancakes, o.j., coffee, tea all for $3.50 adults and $1.75 children under 12. Swap tables $5.00 or bring your own. Admission, including raffle ticket, $1.00. Children, YLs and XYLs free. Open auction 2 PM, raffle 3:30 PM. Computer and Amateur TV displays; an operating 10 meter FM station. Talk in on 147.47 simplex and 146.13/73 local repeater. For information: Darrel, WD6BOR (707) 938-8086. For swap space reservations send $5.00 to VOMARC, 358 Patten Street, Sonoma, CA 95476.

FLORIDA: The Platinum Coast Amateur Radio Society's 17th annual Hamfest, September 11 and 12, Melbourne Auditorium. Swap tables, meetings, forums, awards, tailgating. For information/reservations: PCARS, PO Box 1004, Melbourne, FL 32901.

GEORGIA: The Central Georgia Amateur Radio Club's fourth annual Central Georgia Hamfest and ARRL State Convention, Saturday and Sunday, September 11 and 12, Warner Robins Recreation Center, 800 Watson Blvd., Warner Robins. Indoor and outdoor flea markets at $3.00 per space per day. Bring your own tables. Donation at door $1.00, 6/$5.00 and 13/$10.00. Meetings and forums. Activities for YLs and Harmonics. Talk in on the Frank King Memorial Repeater, 146.25/85. Ample motel space nearby. Hospitality room open Friday night and "pickin' and grinnin' " on Saturday night. For information: Jim Piper, W4HON, 618 American Blvd., Warner Robins, GA 31093.

SOUTHERN ILLINOIS Shawnee Amateur Radio Association's 26th Hamfest will be September 12 at John A. Logan College in Carterville, Illinois. Offerings include air-conditioned flea market, prizes, forums, computers, refreshments, contests. For details QSL Bill May, KB9OY, 800 Hilldale, Herrin, IL 62948 or 618-942-2511 days.

ILLINOIS: The Fox River Radio League again hosts the Illinois State ARRL Convention as part of its annual Hamfest at the Kane County Fairgrounds, St. Charles, Illinois, August 22. Commercial exhibits, flea market, demonstrations, contests, forums, and hot food. Exhibitors, dealers, and vendors contact: G.R. Isely, WD9GIG, 736 Fellows Street, St. Charles, IL 60174. Tickets $2.00 advance, $3.00 at gate. For advance tickets send SASE: J. Dubeck, KA9HQY, 1312 Bluebell Lane, Batavia, IL 60510.

INDIANA: The Tippecanoe Amateur Radio Association's 11th annual Hamfest, Sunday August 15, Tippecanoe County Fairgrounds, Teal Road and 18th Street, Lafayette. Grounds open 7 AM. Tickets $3.00. Flea market, dealers, refreshments and prizes. Talk in on 13/73 or 52. For tickets and information: Lafayette Hamfest, Route 1, Box 63, West Point, IN 47992.

INDIANA: The 3d annual Grant County Amateur Radio Club Hamfest, September 11, McCarthy Hall, St. Paul's Church, Marion. Donation $2.00 advance; $3.00 gate. Refreshments, free parking and hourly prizes. Talk in on 146.19/79 or 146.52 simplex. For information/tickets SASE to Beecher Waters, WB9YHF, RR #1, Box 357, Converse, IN 46919.

IOWA: The Iowa 75 meter Net will hold a picnic and swapfest, Sunday, August 15, River Valley Park, Ames. Pot luck lunch at noon followed by a program and prizes. Talk in on 16-76. For information: WB0JFF, Net Sec.

KENTUCKY: The Central Kentucky ARRL Hamfest sponsored by the Bluegrass Amateur Radio Society, Sunday, August 8, Scott County High School, Longlick Road at US Route 25, Georgetown. Tickets $3.50 advance; $4.00 gate. Flea market, forums, awards. For information: Ernie Cohen, K4DHN.

MAINE: The Augusta Emergency Amateur Radio Unit's Northeast area Hamfest, September 10, 11 and 12, Windsor Fairgrounds, off Route 17, 10 miles east of Augusta. Flea market, speakers, demonstrations and more. Camping facilities available. Talk in on 146.22/82 and 3940. An award will be made to an Amateur from northern New England, Quebec or the Maritimes who has made a significant contribution to Amateur Radio. Nominations should be by letter to Windsor Hamfest Committee, W.E. Jackson, W1WCI, RFD #1, Box 3970, Winthrop, ME 04364.

MICHIGAN: The Grand Rapids Amateur Radio Association's annual Swap and Shop, Saturday, September 18, Hudsonville Fairgrounds. Gates open 8 AM for swappers and public. Prizes, dealers, indoor sales, outdoor trunk swap. Talk in on 146.16/76. For information: Grand Rapids, ARA, PO Box 1248, Grand Rapids, MI 49501.

NEW JERSEY: The Ramapo Mountain Amateur Radio Club, WA2SNA, 6th annual flea market August 21, Oakland American Legion Hall, 65 Oak St., Oakland, only 20 miles from the GW bridge. Admission $1.00; tailgating $3.00. Non-ham family members free. Door prizes include an Icom IC-2AT. Talk in on 147.49/146.49 and 52. For information: Walt Zierenberg, WD2AAI, 344 Union Avenue, Bloomingdale, NJ 07403. (201) 838-7565.

NEW JERSEY: The Sussex County Amateur Radio Club's fourth annual Hamfest, September 11, Sussex County Farm and Horse Show grounds, Plains Rd., Augusta. Registration $2.00. Door prizes. Outdoor flea market sellers: $4 preregistered; $5 gate. Indoors $5 preregistered; $6 gate. Talk in on 147.90/30 and 146.52. For information/registration: Sussex County ARC, PO Box 11, Newton, NJ 07860 or Lloyd Buchholtz, WA2LHX, 10 Black Oak Drive, Vernon, NJ 07462.

NEW JERSEY: 33d annual W3PIE Gabfest, Saturday, September 11, Club grounds, Old Pittsburgh Road, off Route 51 and 119 By-pass, Uniontown. Preregistration $2.00 each, 3/$5.00. Free swap and shop setup with registration. Free coffee. First prize: Ten-Tec Argosy 525 HF. Other prizes VoCom 2 meter amp, 2CO25, V.O.M. Meter, Cushcraft 5 band vertical, Hustler 2 meter beam and many more. DX contest $50.00 cash prize. XYL prizes. Computer, OSCAR demos. Refreshments. Talk in on 147.045-645; 144.57 - 145.17 and 146.52-52. For information: U.A.R.C. Gabfest Committee, John T. Cermak, WB3DOD, PO Box 433, Republic, PA 15475. (412) 246-2870.

NEW YORK: The Elmira Amateur Radio Association's seventh annual International Hamfest, September 25, Chemung County Fairgrounds. Gates open 6 AM, breakfast available. Limited Friday night camping available at fairgrounds. Nearby camping facilities. Free flea market, dealers, door prizes. Grand prize: Icom IC-730 with PS. Second prize: Icom IC-25A. Third prize: Kenwood station clock. Talk in on 147.96/36, 146.10/70 and 146.52 simplex. Tickets $3.00. Advance tickets $2.00 from John Breese, 340 West Avenue, Horseheads, NY 14845.

OHIO: The Findlay Radio Club Hamfest is celebrating its 40th anniversary on September 12, 1982, Hancock Recreational Center Arena, N. Main St., I-75, exit 161. Open 6:30 AM to 5:00 PM. Largest Hamfest in Northwest Ohio, second in state. Tickets $2.00 advance, $3.00 at entrance. Exhibit tables are $5.00 per table. Flea market trunk sales $2.00 per space. Open Saturday for setups and evening entertainment. Talk in 147.75/15. Check in 146.52/52. For reservations and tickets SASE to Findlay Radio Club Hamfest, PO Box 587, Findlay, Ohio 45840.

PENNSYLVANIA: The Skyview Radio Society's annual Hamfest, Sunday, September 19, noon to 4 PM, Club Grounds, Turkey Ridge Road, New Kensington. Registration $2.00. Vendors $4.00. Awards. Talk in on 04-64 and 52 simplex.

PENNSYLVANIA: The Central Pennsylvania Repeater Association's 9th annual *Hamfest/Computerfest*, September 5, Harrisburg Farm Show parking lot, off US Route 81, Cameron St. exit. Gates open 8 AM. Registration $3.00. Sellers $5.00 per 10 ft. space. Tailgating $1.00. Talk in on 144.87/5.47, 146.16/.76 and .52 MHz. For information and map: Irvin Sanders, K3IUY, RD #3, Box FA53, Harrisburg, PA 17112. (717) 469-2185.

PENNSYLVANIA: The Butler County Amateur Radio Association's annual Hamfest, Sunday, September 12, 9 AM to 4 PM, Butler Farmshow Grounds, Roe Airport, Butler. Mobile checkin 147.96/36 and 52 simplex. Directions 147.84/24. Mobile prize awarded. Fly-in (Butler Farmshow Airport). Fly-in prize awarded. Donation $1.00. Children under 12 free. Overnight camping. Indoor flea market $3.00 per 8 ft. table. Free outside flea market. Refreshments. Prizes include: Kenwood TS-830S, Kenwood TR-7730, Kenwood TR-2500 Handheld. For information: Leighton Fennell, Crestmont Drive, RD 6, Butler, PA 16001. (412) 586-9822.

TENNESSEE: The Lebanon Hamfest, sponsored by the Short Mountain Repeater Club, Sunday, August 29, Cedars of Lebanon State Park, U.S. 231, Lebanon. Outdoor facilities only. Exhibitors bring own tables. Refreshments available. Talk in on 146.31/146.91. For information: Mary Alice Fanning, KA4GSB, 4936 Danby Drive, Nashville, TN 37211.

TEXAS: The Texas VHF Society's 1982 summer meeting, August 13, 14, 15, Nassau Bay Resort Motor Inn, Johnson Spacecraft Center, Houston. Special tours of NASA, exhibits, flea market, Ham astronaut speaker, space shuttle communications, VHF & ARRL seminars. Prizes include all-mode VHF transceiver. Preregistration for all three days $5.00 includes one free prize ticket. $1.00 for each additional ticket. Registration at door $6.00, no prize tickets. Talk in on 146.04/.64 and 147.75/.15 repeaters. For preregistration information: Texas VHF-FM Society, Summer Session, PO Box 73, Texas City, TX 77590.

TEXAS: The first annual Wichita Amateur Radio Society's Hamfest, September 25 and 26, National Guard Armory, Wichita Falls. Preregistration $4.00. At door $5.00. Preregistration prize, grand prize, and other prize drawings. Dealers, computer demonstrations, flea market, refreshments. Ladies activities and prizes. Talk in 146.34/94 and 147.75/15. Free RV parking at armory. No hookups. Help celebrate Wichita Falls 100th birthday. Citywide activities.

WASHINGTON: Radio Club of Tacoma Hamfair '82, PLU Campus, Tacoma. 147.28. Contact AD7S.

OPERATING EVENTS

"Things to do..."

AUGUST 14: The Berry's Mountain ARC's first DXpedition commemorating the 165th continuous year of operation of the Millersburg Ferry, founded in 1817, and consisting of two stern-wheel ferryboats left in the United States today. The "Falcon" will carry a 40 meter station and the "Roaring Bull", 20 meters. Other stations will operate dockside. Using the callsign W3TS, club members will operate from 1200 until 2400 GMT. Frequencies: 3.910, 7.045, 7.125, 7.245, 14.045, 14.295, and 147.24/84. For a pictorial commemorative certificate and a full historical survey of this unique and colorful ferry, send your QSL, a business-size SASE and 25¢ to: W3TS, Dana Michael, RD 1, Box 144, Lykens, PA 17048.

AUGUST 29: The first annual DXpedition of the Kansas State University ARC and the Manhattan Area ARS to Flush, Kansas in Pott. County. WØQOO will operate 24 hours continuously beginning 0000 UTC. Frequencies: CW 21.112 MHz or 7.112 MHz. Phone 14.292 MHz or 3.892 MHz. For a handsome 8 × 10 certificate, SASE to WØQQQ, Electrical Engineering Dept., Kansas State University, Manhattan, Kansas 66506.

SEPTEMBER 11: The Canisteo Valley Radio Amateurs will operate special event station WB2SOX from 1400Z to 2100Z to commemorate the 50th anniversary of the "Canisteo Living Sign", the world's largest living sign. Frequencies: 7245, 14.285, 21.375, 28.650 MHz ± QRM. SWLs eligible too. A special aerial color photo QSL of the living sign is available for your QSL plus business SASE to John S. Babbitt, WB2SQX, Square Woods Drive, Canisteo, NY 14823.

SEPTEMBER 11 AND 12: The Cray Valley Radio Society's 12th SWL contest, from 1800 GMT September 11 to 1800 GMT September 12. There will be two sections, phone and CW, each with two categories, single and multi-operator. Bands: 1.8, 3.5, 7, 14, 21 and 28 MHz. Send business SASE for log sheets to Owen Cross, G4DFI, 28 Garden Ave., Bexleyheath, Kent. Entries should be sent to contest manager, G4DFI, at above address no later than November 1, 1982. Certificates of merit will be awarded by the board of the Cray Valley RS.

SEPTEMBER 4-12: The Southern Counties Amateur Radio Association, SCARA, is planning a special events station during the Miss America Pageant at the Atlantic City Convention Hall. Frequencies: 10 through 80 meters on General class phone band 25 kHz up from lower end of band. CW 10 through 80 meters, 65 kHz up from bottom of CW General class portion of CW band. A Novice/Technician station is tentatively scheduled on the CW portion of 40 and 15 meters, 50 kHz up from bottom of band. Also a 2 meter station for the Ham community in the immediate Atlantic City area, 146.52 simplex. The call sign for this special event will be K2BR. For a QSL, SASE to SCARA, Box 121, Linwood, NJ 08221.

THE NORTHERN NEW JERSEY CHAPTER OF QCWA has established its "Elmer Award" to honor all the "Elmers" who, since Marconi, have given their time and talent to help others become Amateur Radio operators. The award will consist of two plaques, one carrying the name of each year's winner and rotating annually; the other, a permanent award, naming the current year's winner. Nominations may be made by any licensed Amateur operator in Northern New Jersey. Nominees must be licensed Amateur Radio operators residing in Northern New Jersey. Written nominations should be sent to Carl Felt, N2XJ, 8 Charles Place, Chatham, NJ 07928 prior to September 1, 1982. Presentation of the 1982 award will be made at the Chapter's annual meeting, Friday evening, November 19 at the Robin Hood Inn, Clifton, NJ.

Designing a box
that protects your gear
by keeping the weather out
but letting the rf in

weathering the elements at 10.4 GHz

Experimenting with 10.4-GHz transceivers can be a lot of fun. But it would be a lot more fun if you could leave your setup on the roof inside a weatherproof enclosure, instead of carrying it up and down the ladder every time you want to operate. This article describes the design of such an enclosure, and also an interesting technique for determining the refractive index at 10.4 GHz of the materials used to build it.

The shape of the enclosure is not important, as long as the one wall of the enclosure through which the 10.4-GHz rf must pass is perpendicular to the direction of rf propagation. The enclosure could simply be a box that is large enough to contain the UHF transceiver and any supporting equipment. The thickness of the enclosure walls, however, and the refractive index (at 10.4 GHz) of the material composing the enclosure walls, are of critical importance. Consider the situation shown in **fig. 1**.

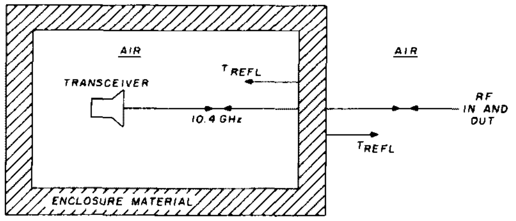


fig. 1. Rf from the transceiver is transmitted through the air inside the enclosure, through the enclosure walls, and then through the air of the outside world. Some of the rf, however, is reflected back into the enclosure. Rf coming from the outside world toward the transceiver experiences the same partial reflection.

By William M. Brooks, WB6YVK, 2050 Southwest Expressway #66, San Jose, California 95126

During transmit, 10.4-GHz waves emanate from the transceiver inside the enclosure, which is filled with air. The radio waves strike the inside wall of the enclosure, a wall composed of polystyrene, nylon, glass, or whatever. The wall will have electromagnetic properties different from those of air. Here is where a problem develops.

When a wave in one medium (such as air) strikes a second medium (the enclosure material) which has a conductivity σ, or permittivity ϵ, and permeability μ, the wave will be partially reflected by the second medium and partially transmitted into it. This partial reflection and partial transmission of the wave occurs because the wave initially propagates in air, with impedance $Z_o = \sqrt{\frac{\mu_o}{\epsilon_o}}$, and then strikes a medium (enclosure material) with impedance $Z_x = \sqrt{\frac{\mu_x}{\epsilon_x}}$.

The reflection coefficient, T_{refl}, can be expressed as:

$$T_{refl} = \frac{Z_x - Z_o}{Z_x + Z_o} \qquad (1)$$

where Z_x = the impedance of the unknown material

Z_o = the impedance of air

and the transmission coefficient, T_{trans}, as

$$T_{trans} = \frac{2Z_x}{Z_x + Z_o} \qquad (2)$$

No reflection will occur when the electromagnetic impedances of the two media are equal, that is, when $Z_x = Z_o$. If the media are perfect dielectrics, that is, those which have no losses (Z is real), we can define SWR as:

$$SWR = \frac{Z_x}{Z_o} \; if \, Z_x > Z_o \qquad (3)$$

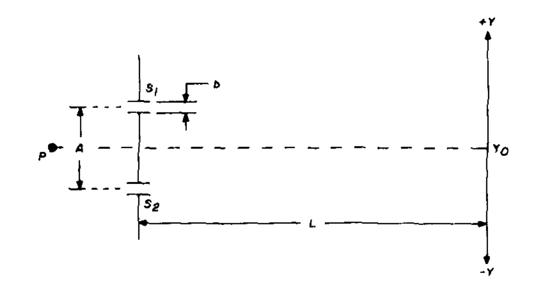


fig. 2. Young's double slit experiment. Slits S1 and S2 act as in-phase radiation sources, resulting in constructive and destructive interference patterns when viewed along axis Y.

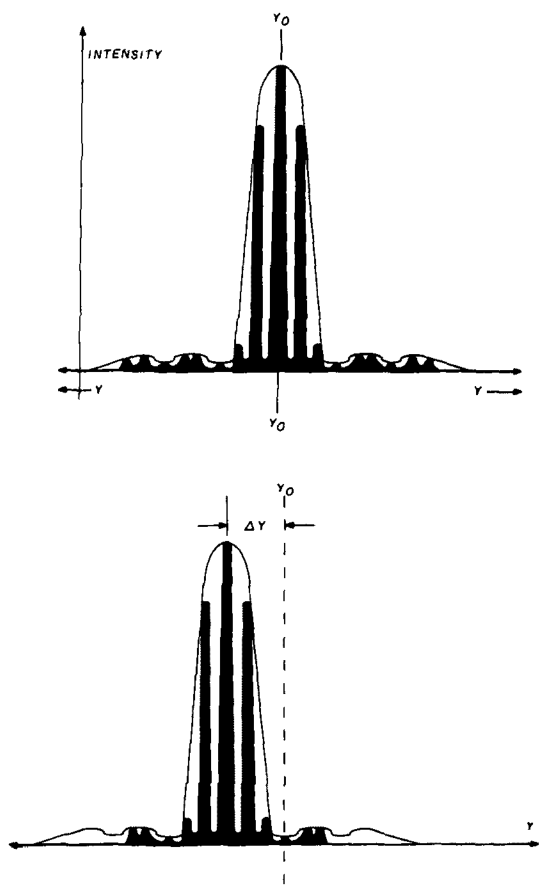


fig. 3. In (A), the intensity envelope seen along axis Y. Maximum intensity is centered at Y_o. In (B), the intensity envelope is seen shifted in the direction of the slit covered by the sample of enclosure material.

$$or \; \frac{Z_o}{Z_x} \; if \, Z_o > Z_x$$

We can eliminate the reflected wave from the air/enclosure-wall interface if we require that the medium outside the enclosure be the same as that inside the enclosure (that is, air inside and outside), and that the wall of the enclosure be $\frac{\lambda}{2}$ thick. The thickness, t_i, of the enclosure walls is then:

$$t_i = \frac{\frac{\lambda}{2}}{\eta_x} \qquad (4)$$

where η_x = the refractive index of the material at 10.4 GHz.

To determine the refractive index at 10.4 GHz of the enclosure material, consider Young's double-slit experiment shown in **fig. 2**. A point source radiator is

located at P. Waves from P propagate to slits S1 and S2, which act as two in-phase radiation sources that are separated by distance A. These two sources cause constructive and destructive interference along the Y axis when viewed at distance L. The intensity at Y is the result of interference and diffraction, expressed as

$$I_y = I_o \, sinc^2 \left(\frac{\pi b y}{\lambda L}\right) \, 4 \cos^2 \left(\frac{\pi A Y}{\lambda L}\right) \quad \textbf{(5)}$$

where: I_y = intensity at screen along Y
b = slit width
A = slit separation
L = distance from slits to screen
I_o = intensity at Y without slits

The intensity envelope described by **Eq. (5)** is shown in **fig. 3A**. Note that the intensity envelope is symmetrical and centered at Y_o.

Placing a sample of the enclosure material in front of one of the slits causes the two slits to radiate out of phase, because of the difference between the propagation velocity through the material and the velocity through air. The result is a displaced intensity envelope in a direction toward the slit with the sample of enclosure material, as shown in **fig. 3B**. The magnitude of this displacement is related to the thickness, t_2, of the sample and its refractive index, η_x:

$$\eta_x = \frac{\Delta Y}{t_2} \frac{d}{L} + \eta_{air} \quad \textbf{(6)}$$

where η_x = refractive index of the material
η_{air} = refractive index of air (1.000276)
d = center-to-center slit separation
L = distance from slits to Y
t_2 = thickness of the sample

practical example

Suppose that we have acquired some material that looks like polystyrene, but we are not certain that it is polystyrene, nor do we know its refractive index at 10.4 GHz.

To determine the refractive index, we construct a simple double slit mask, as shown in **fig. 4**. It can be constructed of cardboard and then covered with aluminum foil. The double slit mask is placed in front of the 10.4-GHz transmitter, as shown in **fig. 5**.

Let the distance, L, between the slit mask and Y be 2 meters. Moving a suitable detector that gives a strength reading along Y, we will observe the intensity envelope as shown in **fig. 3A**. The envelope should be centered at Y_o. Then, when a sample of the material is placed in front of slit S1 and the experiment repeated, we will observe that the intensity envelope has shifted toward the S1 side of Y, as in **fig. 3B**. The thickness of the sample, t_2, in this instance proved to be 25 mm, and the observed envelope shift, ΔY, was measured 0.51 meter. This reveals a refractive index, η_x, of 1.593, using **Eq. (6)**. We now know the refractive index at 10.4 GHz of the material.

Substituting the determined η_x value into **Eq. 4** reveals that the thickness of the enclosure walls has to be 0.90 cm to behave as a transparent medium for 10.4-GHz rf. Thus, by simply constructing a box of this material with walls 0.90 cm thick, we have prevented rain, sleet, and snow from getting into our transceiver, but we allow 10.4-GHz rf to see an open window.

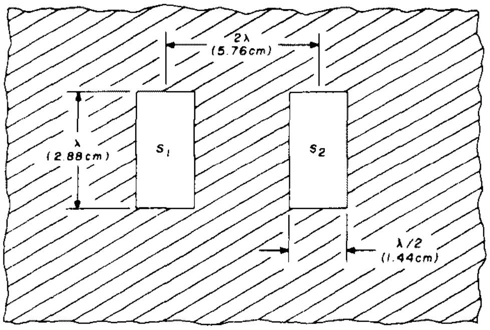


fig. 4. Construction details of the double-slit mask, a device that can be used to determine the refractive index of the material in question. Once the refractive index is known, it is a simple matter to calculate the wall thickness required to make the box appear transparent at 10.4 GHz.

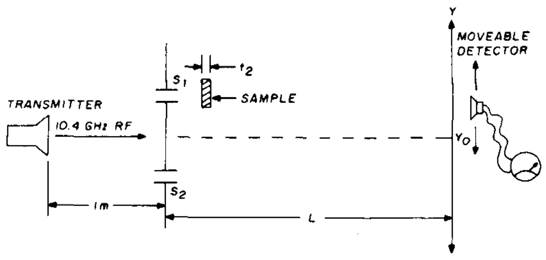


fig. 5. Experimental set-up for determining the refractive index of a sample of the unknown material. Distance between the transmitter and slit mask should be about 1 meter.

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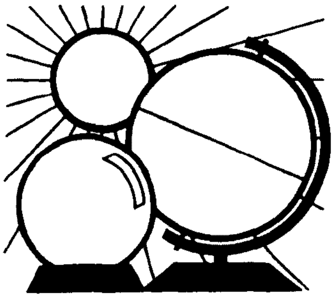
ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last-minute forecast

The higher frequencies (10 and 20 meter bands) are expected to provide good DX openings during the second and third weeks of the month. The beginning and ending weeks will probably see only fair DX conditions on these bands. Nighttime DX conditions, and openings on the lower frequency bands (40 through 160 meters), should be better during these beginning and ending weeks of the month — particularly the last week, when the nights are longer and the thunderstorm QRN that builds up toward evening has subsided somewhat. Geomagnetically disturbed conditions of two to three days' duration probably could provide interesting and unusual DX about the 6th and 17th.

A more extended period of disturbance, which may be evident about the 24th, may be part of a 27-day recurrent pattern of thinning in the sun's corona. This thinning permits the solar wind to travel through to the earth's polar regions, causing geomagnetic disturbances. At this time in the eleven-year cycle the sun is still active enough to produce a strong solar wind, which may cause repeated disruptions of communications during the two years of 1983 and 1984. From then through the sunspot minimum (1985 and 1986), there should be no geomagnetic disturbances caused by either flares or solar wind. The sun becomes so subdued that nothing happens.

The lunar perigee will be on the 17th and full moon on the 4th this month. The Perseids meteor shower occurs between the 10th and 14th, with maximum the 11th and 12th at better than fifty meteors per hour. This is an excellent shower.

forecasting by computer

In the August, 1981, column, I mentioned that the North Atlantic forecast on WWV is essentially the solar flux and geomagnetic A figure. An analytical mathematical formulation has been developed by Mr. John Harris and me as an aid to our forecasters and observers (monitors). Given the daily flux value and daily A value, a number from zero to nine representing radio quality can be calculated. This number can be a baseline number from which each user can adapt his own calibration for his operating mode (CW, phone, RTTY). Many Amateurs have home computers these days. This formula can be programmed on these computers to obtain a daily propagation quality forecast. The formula is:

$$Q = 10\left[\log\left(\sqrt[4]{\phi}\right)^{\theta}\right]\left[e^{-0.01A}\right] + 0.82$$

where ϕ is the daily solar flux, A is the geomagnetic daily value, and

$$\theta = 1.0 + 0.2625 \sin^2 0.49315X$$

where X is the annual day number. Try it. If you have any questions, write to me at Rt. 1, Box 36, Earlysville, Virginia 22936.

band-by-band forecast

Ten and fifteen meters should provide excellent daytime openings. The hours of daylight should begin to be noticeably shorter, particularly toward the end of the month. Watch for the best openings during periods of high solar flux. They should be north/south paths to Africa, South America, and the South Pacific, but they will not be of the one-long-hop trans-equatorial (TE) type that correlate well with geomagnetic disturbances. TE paths are usually scarce in July and August. A sun-following sequence of Africa in the morning (local time), South America in the early afternoon and the South Pacific in the late afternoon is usually seen from most QTHs in the U.S.A. *Fifteen* will be open a little before *ten* and will last a little longer in the evening.

Twenty meters will be open around-the-clock on most days, and will be the long-skip/short-skip workhorse of the high-frequency DX bands. Signals will peak in the morning and afternoon hours but will be readable to one area or another all the day and night.

Forty meters is going to start coming back strong, except for the high QRN levels during local thunderstorms. It can often provide good DX from sunset through darkness till just after sunrise, despite the atmospheric noise levels — provided you choose times when local thunderstorms are at a minimum.

Eighty and one-sixty meters will become active once again for DX during the nighttime hours, with strong openings into the south. High QRN levels will still be a problem generally, but the bands will be usable between local thunderstorms.

ham radio

AUGUST

WESTERN USA

GMT	PDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
0000	5:00	15	—	20	15	—	10	10	15
0100	6:00	15	—	20	15	—	10	10	15
0200	7:00	15	—	20	15	15	10	10	15
0300	8:00	15	—	20	15	15	10	10	15
0400	9:00	15	—	20	20*	15	10	10	15
0500	10:00	20	—	20	20	20	15	15	15
0600	11:00	20	—	20	20	20	15	15	20
0700	12:00	—	—	20	20	20	15	15	20
0800	1:00	—	—	20	20	20	15	15	20
0900	2:00	—	—	—	—	20	20	15	20
1000	3:00	—	—	—	—	—	20	15	20
1100	4:00	—	—	—	—	—	20	20	40
1200	5:00	—	—	—	—	—	40	20	40
1300	6:00	—	20	—	—	—	40	20	40
1400	7:00	20	20	—	—	—	20	20	40
1500	8:00	20	20	15	—	—	20	20	20
1600	9:00	20	20	15	15	20	—	20	20
1700	10:00	20	15	15	10	15	—	—	20
1800	11:00	15	15	15	10	15	—	—	—
1900	12:00	15	15	15	10	15	10	—	—
2000	1:00	20	15	15	15	15	10	—	—
2100	2:00	—	20	15	15	15	10	10	15
2200	3:00	—	20	20	15	15	10	10	15
2300	4:00	—	20	20	15	—	10	10	15

MID USA

GMT	MDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)	CDT
0000	6:00	15	20	20	15	—	10	10	15	7:00
0100	7:00	15	20	20*	15	—	10	15	15	8:00
0200	8:00	20	20	20	15	15	10	15	15	9:00
0300	9:00	20	20	20	20	15	15	15	15	10:00
0400	10:00	20	20	20	20	20	15	15	20	11:00
0500	11:00	20	20	20	20	20	15	15	20	12:00
0600	12:00	20	20	20	20	20	15	20	20	1:00
0700	1:00	20	20	—	20	20	20	20	20	2:00
0800	2:00	20	—	—	20	20	20	20	40*	3:00
0900	3:00	—	—	—	20	20	20	20	40	4:00
1000	4:00	—	—	—	—	—	20	20	—	5:00
1100	5:00	—	20	—	—	—	20	20	—	6:00
1200	6:00	—	20	—	—	—	20	20	—	7:00
1300	7:00	—	20	15	—	—	20	20	—	8:00
1400	8:00	—	20	15	10	—	20	20	—	9:00
1500	9:00	20	20	15	10	—	—	20	—	10:00
1600	10:00	20	15	15	10	—	—	—	—	11:00
1700	11:00	20	15	15	10	—	—	—	—	12:00
1800	12:00	15	15	15	10	15	—	—	—	1:00
1900	1:00	15	15	15	10	15	10	—	—	2:00
2000	2:00	20	15	15	10	15	10	—	15	3:00
2100	3:00	20	20	15	10	15	10	10	15	4:00
2200	4:00	20	20	15	10	15	10	10	15	5:00
2300	5:00	—	20	20	10	15	10	10	15	6:00

EASTERN USA

GMT	EDT	N (ASIA FAR EAST)	NE (EUROPE)	E (S. AFRICA)	SE (CARIBBEAN S. AMERICA)	S (ANTARCTICA)	SW (NEW ZEALAND)	W (OCEANIA AUSTRALIA)	NW (JAPAN)
0000	8:00	15	20	20	15	20	15	15	15
0100	9:00	20	20	20	15	20	15	15	20
0200	10:00	20	20	20	15	20	15	15	20
0300	11:00	20	20	20	15	20	20	20*	20
0400	12:00	20	40	20	20	20	20	20	20
0500	1:00	20	40	20	20	20	20	20	20
0600	2:00	20	40	—	20	20	20	20	20
0700	3:00	—	—	—	20	20	20	20	20
0800	4:00	—	—	—	20	20	20	20	—
0900	5:00	—	—	—	20	—	40*	20	—
1000	6:00	—	—	—	20	—	40*	20	—
1100	7:00	—	20	—	—	—	40	20	—
1200	8:00	—	20	15	15	—	20	20	—
1300	9:00	20	15	15	10	—	20	20	—
1400	10:00	20	15	15	10	—	—	20	—
1500	11:00	20	15	15	10	20	—	20	—
1600	12:00	20	15	15*	10	20	—	—	—
1700	1:00	20	15	15*	10	15	—	—	—
1800	2:00	15	15	15	10	15	—	—	—
1900	3:00	—	15	15	10	15	—	—	—
2000	4:00	—	20*	15	10	15*	15	—	—
2100	5:00	—	20	15	10	15	10	15	20
2200	6:00	15	20	20	15	15	10	15*	15
2300	7:00	15	20	20	15	15	15*	15	15

NEW products

IC-730 HF transceiver

ICOM announces the IC-730 compact solid state high-frequency transceiver. The IC-730 is specifically designed for the budget-minded ham. It's priced at $829.00, making it affordable as a second transceiver for mobile/portable operation, or as the main high-frequency base station transceiver.

The IC-730 is compact, only 9.5 × 3.7 × 10.8 inches. It has 10-80-meter frequency coverage including all three new WARC bands; it has fully synthesized tuning for stability in mobile operation (1 kHz, 100 Hz, 10 Hz steps). Other features include dual VFOs standard; eight-frequency memory storage (one frequency per

band); fully solid-state circuitry with automatic final protection; and i-f shift standard with passband tuning optional.

For more information, write ICOM, 2112 116th Avenue, Bellevue, Washington 98004.

CW89 software package

Hams who own Heath computers can send and receive Morse code with the new CW89 software package from Commsoft. This program includes a split screen display, 4-99 WPM operation, receive autotrack, a 1000-character pretype buffer, ten user-definable messages, unique break-in mode, on-screen system status, disk I/O, hard copy, and a versatile code practice section.

The CW89 allows the user to practice code at variable speeds in several formats: alphabet only, alphabet and numbers, or all common Morse characters with or without random spaces. Practice code can come from one of one hundred disk files that can be prepared using a standard text editor. All communications and practice texts can be sent to a printer or stored on disk. The CW89 program runs on the Heath H-8/H-19, H-89 or Zenith Z-89 computers under HDOS. One disk drive and 32K RAM are required. A hardware interface, such as the Commsoft Codem, is also required.

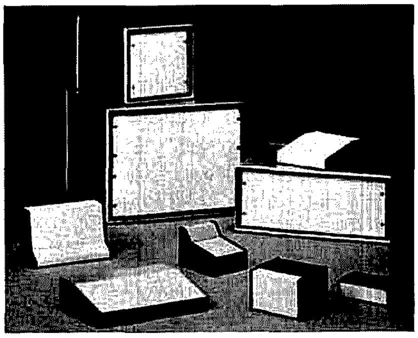
The price of the CW89 is $99.95, postpaid. A complete package consisting of CW89, the Codem, a computer interconnect cable, power supply, complete documentation, and shipping is available for $249.95. California residents add applicable sales tax. VISA and MasterCard orders accepted.

For more information, contact Commsoft, 665 Maybell Avenue, Palo Alto, California 94306; telephone 415-493-2184.

Ten-Tec enclosures

Ten-Tec, Inc., announces a newly expanded enclosure line. The new models include high-style concepts in metal and metal-plastic combinations in larger bench and portable sizes.

The new series 9 and 19 metal cabinets accept panel heights from 3.5 inches up to 17.5 inches, and widths of 9.5 inches and 19 inches. Depths are 14.4 inches and 18.4 inches. Thirteen sizes are standard. Construction is welded aluminum. Standard rack panel mounting rails are provided at both front and back with interior racks for guide rails. Recessed side handles are provided in larger cabinets; smaller sizes use collapsible top handles. Styling features extruded aluminum front and rear edge bezels with walnut or black trim inserts. Standard textured finishes include blue, orange, black and dark brown. Optional front panels are offered in a variety of sizes with custom finishes. Special sizes, finishes and panel punching is available.



The new series S, H, and V use both metal and metal/plastic combinations featuring sloping front panels for keyboard and switch cluster configurations. Series S has 3-inch heights and four widths from 6.5 to 14 inches. Depths are 9 inches. The all-aluminum cabinets are available in standard textured finishes of blue or black with satin-aluminum or beige panels. Series H and V have metal chassis and plastic sides in walnut or black textured finish. All three in this group have sloped and upright front panels.

For complete information, contact Ten-Tec, Inc., Highway 411 East, Seiverville, Tennessee 37862; phone 800-251-9350.

West-Coast repeater directory

The new all-band 1982 VHF/UHF repeater directory is available from Gordon West, WB6NOA. Over seven hundred repeaters in California, Mexico, Arizona, Nevada, and Hawaii are

NEW products

listed in easy-to-read type in this twenty-page repeater log. Repeaters on 10 meters, 6 meters, 2 meters, 220 MHz, and 450 MHz are listed by frequency. The call letters and area of coverage are also noted beside each repeater listing. There are also notes on tones or special functions of each repeater.

Now in its third year of printing and update, this large-format repeater log is the ultimate for accurate and easy-to-understand repeater information. Repeater offsets are given as simply A (+) or (−) to simplify the process of finding the right repeater for your area of operation.

The West-Coast Amateur Radio all-bands repeater log is available at local ham radio stores throughout the southwest. Quantity club and store discounts are also available. Individual copies will be sent out first class mail for $2.50. Write: West Coast Repeater Log, 2414 College Drive, Costa Mesa, California 92626.

Communications Concepts Model 335 fm class-C amplifier kit

Two-meter fm has done more to popularize Amateur Radio than any other mode of communications. In the early days, most hams used surplus commercial two-way transceivers. Then came crystal-controlled transceivers designed specifically for ham use. And now, with advanced CMOS design, you can get a handheld, synthesized radio that will do more than the surplus radios ever could — except for one thing: The new radios all run on significantly less power.

For many hams that isn't a problem at all. But for us here at *ham radio* it's a big problem. In the hills of southern New Hampshire, the small handheld radios simply don't have enough power. Even some of the larger and more powerful radios have trouble from time to time.

There is a way to beat the problem, however, and that is to run an amplifier. Communications Concepts' Model 335 amplifier kit has been designed so that it can be used either at home or in the car. The basic design is class-C, for low power consumption, but provisions have been made to enable you to bias the amplifier class AB, allowing it to be used as an SSB/fm/CW amplifier. The amplifier is quite small and unobtrusive.

Circuit board and materials are all of first-rate quality, and there is very little chance of failure resulting from a defective board or part. An equally important consideration is the excellent instruction booklet. The instructions for assembly are accurate and easy to follow. Since we couldn't devote a whole evening to the project, it was spread out over a span of several nights. There was no problem picking up where we'd left off the night before. That is a real big plus. Construction time was no more than three hours, and the only problem was with the BNC connectors. Our station is set up with UHF connectors throughout, so a few adapters were needed. Not a problem, just a minor inconvenience.

After all the parts were in place, tune-up was relatively simple. The instructions clearly show how it's done, and hints are provided should there be any problems. All that's needed is to adjust input and output capacitors for maximum power.

Placement of the unit is up to the good judgment of the builder. Past experience has taught us that there are several places *not* to put the unit. The first is near the heater output. Many years ago we had another amplifier that failed because of severe overheating, a problem traced to the car's heater. Another good location to avoid is under the seat. Some of the newer cars do not have much clearance, and sliding the seat back and forth can result in tearing the underside. Finally, be careful if you mount the unit on the firewall. We once drilled into the heater core attempting that one. What a mess!

As you would expect, increasing power from 1.5 or 2 watts to 30 increases your radio's capabilities tremendously. We found that in places where accessing a repeater had once been a problem, we were now D.F.Q. Communications Concepts Model 335 VHF amplifier is a nice unit for the ham who wants to put something together and at the same time improve his station's performance.

The editors.

This review was written before the new 335 A-K was released. See May, 1982, page 84 ham radio *for the latest version of this amplifier.*

mobile transceiver

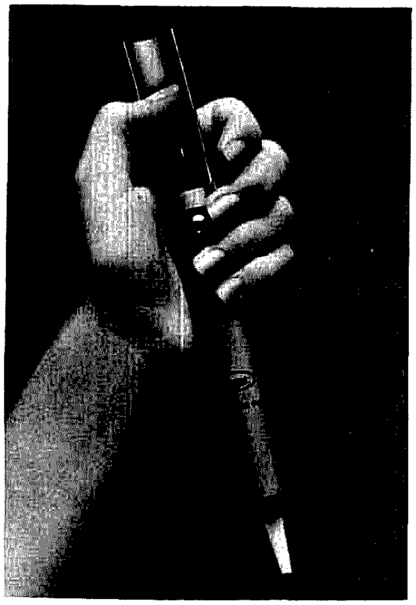
Trio-Kenwood Communications announces the new TR-9130 2-meter fm/SSB/CW 25-watt mobile transceiver, with six memory channels, memory scan, automatic band scan, dual digital VFOs, digital display, noise blanker, high/low power switch, amplified AGC, and a host of other quality features. The TR-9130 is available in two versions, with a basic **UP/DOWN** pushbutton microphone or with a sixteen-key autopatch **UP/-DOWN** microphone.

For additional information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

NEW products

desoldering pump

A desoldering pump that can be operated with one hand and without external power has been introduced by the Ungar Division of Eldon Industries. A spring-loaded piston creates a vacuum that instantly removes molten solder. Double O-ring piston-seals achieve maximum vacuum in a piston stroke of less than two inches. The piston is set with the thumb and released by pushbutton for maximum spring force. The worker's other hand is left free to hold the soldering iron that melts the solder.



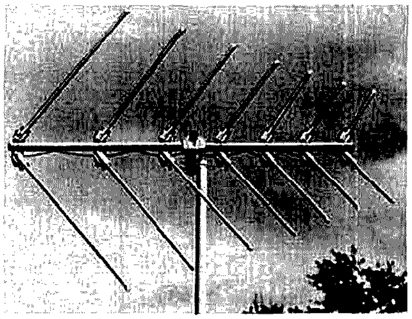
The Ungar 7874 vacuum desoldering pump is made of anodized aluminum and includes a self-cleaning, no-clog Teflon tip that is replaceable. The unit is sufficiently reliable, effective and low in static electricity for use in plant assembly or repair operations, and it's small enough to be carried in tool boxes for field use. The list price is only $14.95.

For further information, contact Ungar, 100 W. Manville St., Compton, California 90220; telephone 800-421-1538.

wideband transceiver antenna

Originally designed as a highly directional base station receiving antenna, the Scanner Beam antenna in recent tests has provided forward rf signal radiation of six times transmitter input power. A 10-watt transceiver sounded like a 60-watt base station. Average VSWR throughout the VHF/UHF bands was a low 1.6:1. Because of its highly directional design, forward signal radiation could be "targeted" toward distant repeater or base stations, thereby increasing the range of low-powered handheld transceivers — and all of this without the use of auxiliary power or expensive preamps.

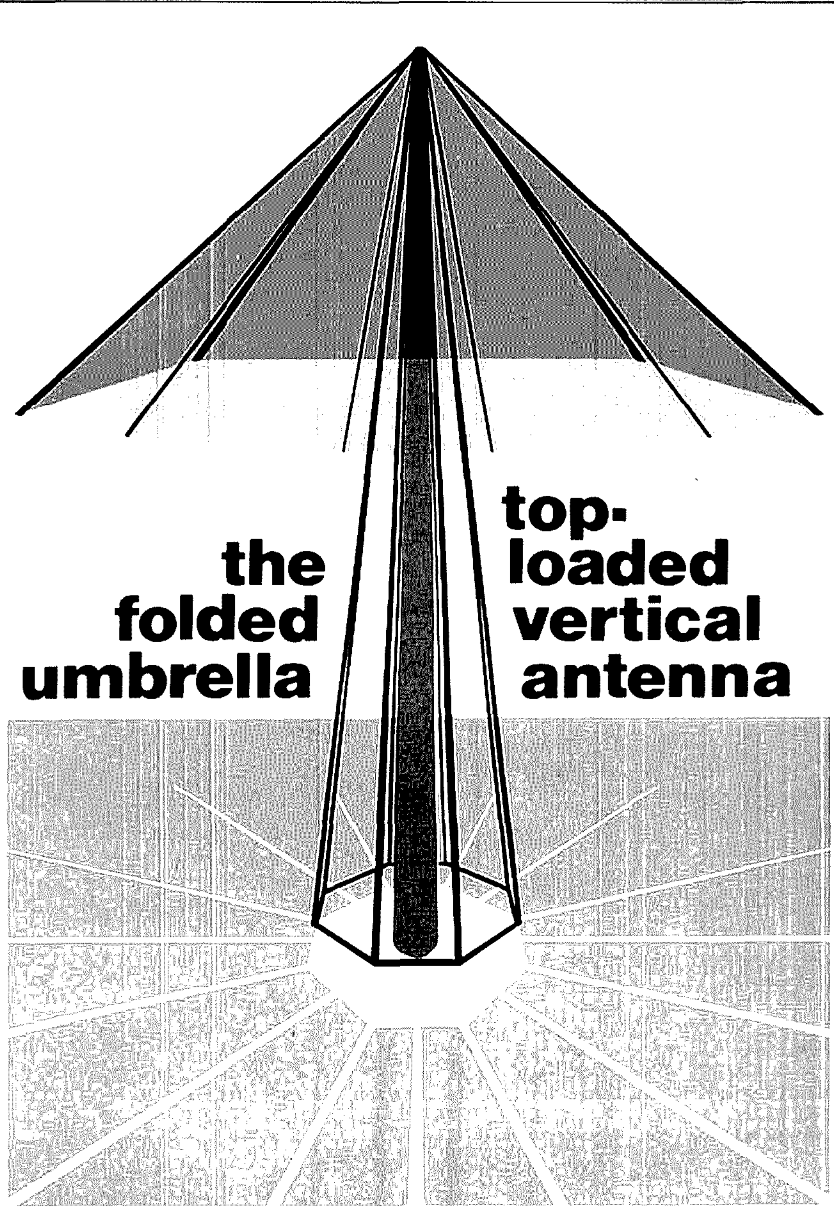
Hams have discovered excellent transmit/receive performance on 144-148, 220-225, and 420-450 MHz. For additional information, write Grove Enterprises, Inc., Dept. D, Brasstown, North Carolina 28902; telephone 704-837-2216. The ANT-1 Scanner Beam antenna may be ordered direct by calling 1-800-438-8155.



SEPTEMBER 1982 / $2.50

ham radio magazine

- a full-size, lightweight quad
- operation upgrade: part 9
- phase-lock techniques for frequency control
- curing obnoxious autopatch habits



hr

focus on communications technology

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contents

Observation & Opinion

The code-free license . . . the end of Amateur Radio?

On July 1 the FCC commissioners directed their staff to prepare a Notice of Proposed Rule-Making for a code-free Amateur Radio license. As reported earlier in "Presstop," the suggested alternatives include deleting the CW requirement for the Technician license and developing a new Digital license, such as the license now in effect in Canada.

Any proposal for a code-free Amateur license always seems to stir strong emotions in the bosoms of U.S. Amateurs. The concept was firmly rejected just a few years ago when Amateur restructuring (Docket 20282) was under consideration. In response to this new proposal, which seems to have strong, important support from within the FCC, the League has already indicated in the July 9 "Directors' Letter" that it will be taking a firm stand in opposition to any license without a code requirement, based on the ARRL Board action taken at the 1982 Annual Meeting.

Let's back off a bit and review where Amateur Radio is today and how it got there. When Amateur Radio began, code was a necessity since, with spark gaps and crystal detectors, that was the state of the communications art. Even the development of the vacuum tube and radiotelephony didn't significantly alter the value of CW for communication since it was so much more efficient in spectrum and power than a-m telephony. But this is 1982, not 1922, and the technology of wireless and Amateur Radio has made incredible advances in those 60 years.

Most Amateur high-frequency voice operation today uses SSB, a spectrum-conserving, power-efficient mode of communications. Non-voice operation, on the other hand, employs radio-teletype, fast/slow scan ATV and facsimile. In addition, the growing popularity of computers is starting to have an impact on Amateur Radio in the newer forms of communications, such as packet radio and spread-spectrum. In light of these developments, is CW still needed for every Amateur Radio license?

Japan has a code-free Amateur license, and as a result it has the largest and fastest growing Amateur population in the world. Japan's Amateur marketplace has become the healthiest in the world, capable of supporting more companies who produce more new Amateur Radio products than the rest of the world combined. But that's not why we at *ham radio* are advocating that we all take an open-minded look at a no-code Amateur license.

The decision to publish this editorial was very difficult. One might easily say that of course we would want a no-code license since the growth in licensed Amateurs would be good for our business. Actually, we did some real soul-searching to absolutely ensure that our decision came truly from our hearts as the best route for Amateur Radio, and was absolutely not made for business considerations. We sincerely believe some form of code-free Amateur license will best serve the long-term interests of all Amateurs and of the Amateur Radio service.

Projections have been made of the great numbers of new licensees that will appear as soon as the no-code policy is adopted. We think this is overstated. Under one proposal currently offered by the FCC, the license candidate is still going to have to pass at least the equivalent of the Technician/General class written exam. For most people this is probably an even greater hurdle than five words per minute of Morse code. This is especially true in light of the new examination proposals discussed in our July editorial. It now appears these will become real possibilities and could largely eliminate the quick and easy type of answer-memorizing license study.

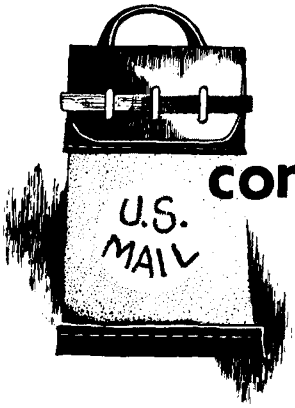
The greatest threat to Amateur Radio in the United States today is not a code-free Amateur license. It is restrictive legislation like that of Burbank, Illinois, discussed in last month's editorial. It is the encroachment of other services like cable TV, whose continued use of 144 and 220 MHz channels must eventually lead to a confrontation whose outcome is far from clear. It's even the shifting pattern of housing, with economic considerations putting more and more Amateurs into condominiums and other multiple-family dwellings where the opportunity to put up an antenna or even operate a transmitter is severely restricted.

The FCC has indicated its interest in granting Amateur Radio the strongest voice in licensing procedures and regulations that we've ever had. This spring saw a significant change in the upper-echelon leadership at the ARRL. Perhaps the time has come to discard the "what's good enough for grandpappy is good enough for you" mentality that's long saddled any discussion of a no-code license, and consider just how such a license could be incorporated into our Amateur structure without cheapening what we've got.

A growing Amateur Radio is a strong Amateur Radio, and if CW is indeed scaring off today's computer-oriented young people, it's time we did something to bring them back. Remember, a code-free license, whether it's entry level or only for very limited privileges, would not mean that CW itself — or the requirement that CW be mastered in order to achieve greater operating privileges — need ever change!

Joe Schroeder, W9JUV
associate editor
Skip Tenney, W1NLB
publisher and editor-in-chief

W9JUV and *ham radio* Publisher W1NLB are both Extra Class licensees, and both spend almost all their low-band operating hours on CW. For the past several years W9JUV's principle contest activity has been in the various DX contests, using an HW-8 barefoot.



comments

converting the vertical-vee

Dear HR:

A really interesting antenna dubbed the vertical-V caught my eye a year ago. I had to have one.

I built the V for 10 meters, using 8-foot elements. Then, a year later, I decided to get another antenna. Since the V was still in good condition, I made it into a delta loop. The full-wavelength delta has 2 dB gain, and the V has none. More importantly, the vertical is already half a delta loop!

To make the modification, I simply added 2 feet to the length of each element and strung copper wire at the tops of the arms (15 feet for 10 meters) — and unbelievably, it worked!

If you have a vertical-V, please convert it. Believe me, no other mod you're likely to make can beat this one.

Martin Reeves, KA5KWV
Dallas, Texas

hurrah for Bill

Dear HR:

I'd like to nominate Bill Orr, W6SAI, (Ham Radio Techniques) for a Distinguished Service Award for Excellence in Technical Writing.

For more than a quarter century, his ability to communicate complex concepts in a lucid, logically coherent, and systematic manner has made a significant contribution to Amateurs, professional engineers, and research people. I am continually amazed by his ability to refresh and renew, with a dash of humor and wit, my understanding of topics I had long lost a grasp of, or failed to follow, since the pre-transistor days when I first became an Amateur.

Thanks for his imaginative time-flight into Amateur Radio, circa 2015, A.D. (*ham radio*, May, 1982). I didn't know whether to laugh or cry; I did both!

Best wishes to W6SAI and *ham radio*, always. I hope Bill Orr will be writing for you right through 2015!

Marty Wincott, K2BRY
Harrison, New York

inductance meter

Dear HR:

I constructed Ed Marriner's (W6XM's) inductance meter (*ham radio*, April, 1982) using parts that I had on hand. Here are two changes I made that others who build this unit might be interested in.

I used a PNP transistor in the tuned stage so that the tuning capacitors would be at ground and it wouldn't be necessary to insulate it from the chassis. The emitter was returned to + 12 volts through 390 ohms and the collector through the tuned circuit to ground. The bias resistors were also reversed.

I needed more sensitivity with my transistors for the metering circuit to work, so I added a 27k resistor from + 12 to the base of the metering circuit transistor.

Norman R. Fisher, WB2LAO
Tuckerton, New Jersey

phonetics

Dear HR:

Concerning KA6NFD's letter in the May issue, I say *brava* to the lady. Those she disagrees with are tin soldiers and moldy figs!

In extremely structured situations, such as MARS, official phonetics are mandatory because of the quasi-military frame of reference. The types who attempt to infuse all of Amateur Radio with that sort of inflexible conformism are, in a way, reminiscent of those who burned heretics at the stake. Regimentation is all right for some, I suppose. But how can anyone ever succeed in achieving one-hundred percent conformity in an activity that involves more than a quarter million individuals? And what on earth would be gained by it?

I happen to like using K2 Always Going Zigzag; on the day the FCC makes it mandatory for me to use Alfa Golf Zulu, I will change it. But until then, I will ID according to my personal preference.

Dave Mann, K2AGZ
Kinnelon, New Jersey

for the blind ham

Dear HR:

The Smith-Kettlewell Technical File is a technical journal aimed specifically at the blind and visually impaired Amateur, hobbyist, student, and professional. It's available quarterly at low cost in Braille, large print, and in Talking Book form.

The purpose of the Smith-Kettlewell Technical File is to provide access to state of the art devices, circuits, and techniques for the visually handicapped. It typically includes articles on soldering and construction techniques, IC pin diagrams and application notes, the design of practical aids and the adaptation of test equipment, and bibliographies of technical materials.

The first issue is free. Contact William A. Gerrey, editor, Smith-Kettlewell Institute of Visual Sciences, 2232 Webster Street, San Francisco, California 94115; telephone 415-561-1619.

Bill Gerrey
Editor, S-K Technical File

Also of interest to the blind Amateur may be the Braille DX Service. Contact them at 8347 West 6th Avenue, Lakewood, Colorado 80215. **Editor**

presstop de W9JUV

A CODE-FREE U.S. AMATEUR LICENSE NOW SEEMS ALMOST CERTAIN, with the FCC staff instructed by the Commissioners July 1 to prepare a Notice of Proposed Rule Making for release later this year. Several alternatives will probably be offered in the NPRM, but the one that seems to have the strongest Commission support is to simply drop the CW requirement from the Technician Class and make it the "Code-Free" license.
Though A Codeless License Is Drawing Increasing support from the Amateur community, the ARRL has already stated its complete opposition to eliminating the CW requirement.

ARRL WILL SUPPORT THE BURBANK (ILLINOIS) LAWSUIT, discussed in last month's "Observa-and Opinion." In a special July 9 meeting, the Executive Committee authorized the expenditure of up to $7500 of League funds to fight the anti-tower and RFI legislation.
The Suit Should Be Filed during August in the U.S. District Court for the Northern District of Illinois, and will seek injunctive relief against enforcement of the ordinance and a declaratory judgment that it is unconstitutional. Constitutional challenges will include the violation of the Amateur and CB operators' right to communicate, intrusion into areas reserved for the Federal government, and violation of due process and equal protection under the law, since it applies only to Amateur and CB antennas.
Despite The ARRL Contribution And Substantial Donations from area clubs and individual Amateurs, additional funding will almost surely be required before this battle is resolved. Contributions to the Burbank Tower Fund can go to Fund Chairman WA9EKA.

420-435 MHZ SHARED USED BY COMMERCIAL RADIOLOCATION WAS AUTHORIZED by the FCC July 22. Meeting on General Docket 80-135, the Commissioners authorized Del Norte Communications to operate spread-spectrum radiolocation throughout the continental U.S. and Alaska, on a non-interference basis. Responding to Amateur objections to the original proposal, the FCC limited Del Norte to spread-spectrum for all its inland operations, and its transmitters must identify periodically by sending "DN" in Morse Code in such a way that it can be copied on a conventional receiver.
Permitting Del Norte On 420-435 MHz Is Not All Bad; Land Mobile has had designs on that part of the spectrum for some time, and the Commission decision to put radiolocation there on a shared basis should protect it from complete loss to Amateurs, as in Canada.
Further Power Limits On 420-450 MHz Amateur Operations near certain military installations have been announced by the FCC in an unrelated action. Effective August 16, 1982, Amateurs within a 100-mile radius of Otis AFB, Massachusetts, Elmendorf AFB, Alaska, and Grand Forks AFB, North Dakota, are limited to 50 watts ERP. The same power limit applies to Amateurs within a 150-mile radius of Beale AFB, California.

A NEW LEAGUE NEWSLETTER WAS JUST ONE of several significant developments to come out of the ARRL July Board meeting in Cedar Rapids. The new publication, which will replace the present "Directors' Letter," will be a bi-weekly that will not only be distributed free to League officials and appointees, but will also be available on a subscription basis to members. Unlike other Amateur Radio newsletters, the ARRL offering will be primarily oriented toward League matters and concerns rather than toward Amateur Radio in general. The initial issue should be published before the end of the year.
New Ad Hoc Committees Were Also Established by the Board to deal with Washington representation, strengthening the CRRL, the Intruder Watch program, and future Amateur volunteer monitoring and exam programs.
An Informal, Off-The-Record meeting with Personal Radio Bureau Chief Jim McKinney was another highlight of the Board's weekend. Although reports of the session are not available, it's certain that the no-code license and similar topics got a thorough going over.

SIX MONTHS IN PRISON PLUS FIVE YEARS PROBATION with 1500 hours of community service was the sentence meted out June 28 to Richard Burton, ex-WB6JAC, by U.S. District Court Judge Manual Real. Burton was convicted June 8 of continuing to operate his Amateur station despite having lost his license a year ago for jamming and indecent language violations. Judge Real had ordered Burton to start serving his sentence immediately, but another judge has since permitted his release on bond pending possible appeal.

NEW METHODS OF SPECIFYING AMATEUR POWER LIMITS are to be proposed in a Notice of Proposed Rule Making that should be released in August. The NPRM, believed to be about ready for presentation to the Commissioners at presstime, will recommend changing the traditional power input limits to power output limitations.
What Output Level Will Actually Be Recommended is still to be decided.

NEW THIRD-PARTY TRAFFIC AGREEMENTS ARE NOW IN EFFECT between the U.S. and Australia, Antigua, and St. Lucia. In addition, the FCC has announced that a reciprocal licensing agreement has been signed with Belize.

THE UOSAT AMATEUR SCIENTIFIC SATELLITE IS STILL LOCKED UP by the inadvertant simultaneous activation of both beacons. New efforts to overcome the resulting receiver desensing and command it back into proper operation are under way in California, where SRI's old 150-foot parabola has been brought out of retirement. Its 432 MHz gain is 42 dBd, yielding an incredible 12 megawatt ERP when driven with 750 watts of rf!

folded umbrella top loaded vertical antenna

Design data for operation on 160 meters — adaptable to any band

Interest in the 160-meter band has traditionally been limited to a persevering few who delight in the technical challenge of working DX on this "top band" — almost to the exclusion of operation on the other bands. The antenna requirements and the lack of suitable equipment have, to some extent, restricted operations on this band. For example, until recently, few transceivers tuned to the 160-meter band, and most antenna tuners would not tune to this band. Today, however, nearly every manufacturer of Amateur Radio equipment has one or more transceivers that tune to 160.

Popular antennas for the 160-meter band are various versions of wire radiators. For example, the series of articles by Bob Eldridge[1] describes a double-size G5RV antenna and the G8ON antenna, which is an up-over-down-and-back version of the former. This latter description gives some insight into the problem. Most wire antennas are also too close to the ground to provide good low-angle radiation, and the construction of an efficient vertical antenna for DX is considered by most to be out of reach. A quarter-wave tower antenna would be 125 feet (38 meters) high at 1.815 MHz, which is higher than most Amateurs care to go, and a 5/8-wavelength antenna (an ideal DX antenna) would be 309 feet (94 meters) high.

Practical considerations with regard to height and size usually mean that some form of capacitive top loading must be used to limit the height of the

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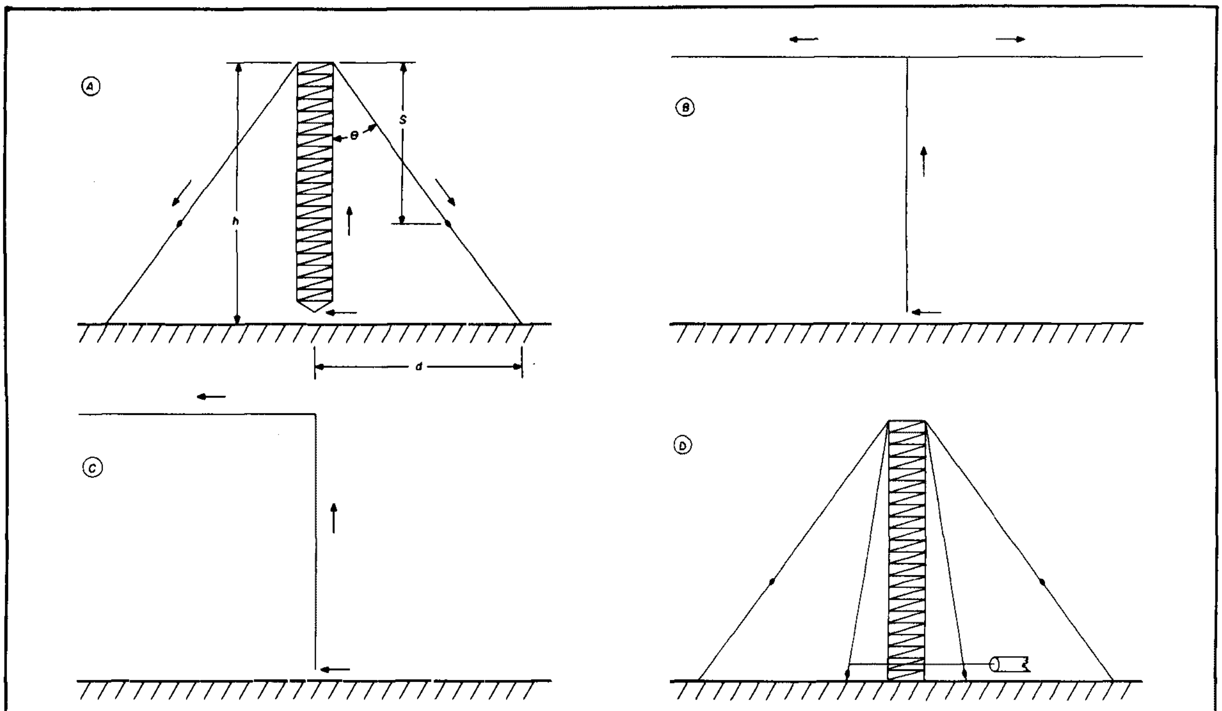

fig. 1. Wire antennas discussed in the text. *A*, the umbrella type top loaded vertical antenna, base-insulated tower (arrows illustrate the phasing of the current on the antenna). *B*, T-type top loaded vertical radiator (insulated base). *C*, L-type top loaded vertical radiator (insulated base), and *D*, folded umbrella antenna.

antenna. The *ARRL Antenna Handbook*[2] illustrates several methods to realize practical 160-meter antennas; grounded towers supporting plumber's-delight (grounded) beam antennas can be shunt fed for 160-meter operations as described by True.[3] In fact this is probably the easiest way to achieve satisfactory operation on this band. Various methods of constructing and feeding 160-meter antennas have been described by Booth.[4]

One of those briefly discussed in the *Antenna Handbook* was the umbrella top-loaded vertical radiator. The umbrella antenna is more economical than the T- or L-type radiators because, for the same peformance, it uses only one mast. The other types require two. A further simplification is obtained by folding the vertical element to raise its impedance to that required by the feedline which, if the antenna is resonant, can be connected directly to the transmission line without the need of a matching circuit. While such an antenna is used for fixed point-to-point communications and for broadcasting (Nolan[5]), it is virtually unkown to Radio Amateurs. Furthermore, published information on the umbrella antenna does not give curves that are useful for design. This article explains how to design an umbrella antenna, and it will be shown that a mast height of about 1/10 wavelength (54 feet, or 16.5 meters at 1.815 kHz) can be designed for a radiation efficiency of 70 percent or better, and bandwidth of 200 kHz or less.

the umbrella antenna

The umbrella top-loaded antenna is illustrated in **fig. 1A**. The top loading consists of a number of wires strung obliquely to ground from the top of the radiator, and insulated from the ground. The important parameters for such an antenna are the height, h, of the radiator, the horizontal distance, d, from the base of the radiator to the extremities of the guys supporting the umbrella wires, and the vertical distance, s, from the top of the tower to the height at which the umbrella wires are broken by an insulator. This antenna was first used by Smith and Johnson[6] at broadcast frequencies in 1947. It was investigated experimentally by Belrose, *et al*;[7] and by Gangi, *et al*.[8] These authors, along with Smeby,[9] examined the antenna theoretically. Smith and Graf[10] have experimentally investigated umbrella antennas using multiwire rib construction, which is particularly applicable for very short antennas at VLF.

The sketches in **figs. 1A, B,** and **C** show by the direction of the arrows the phasing of the currents on the umbrella top-loaded vertical, the T-, and the L-type antennas thus illustrating the difference be-

tween these types of radiators. In the case of the T- and L-type radiator, the currents on the flat top and the vertical part of the radiator do not interfere, since these currents are orthogonal to each other in space. Recall that only the currents on the vertical part of the radiator contribute appreciably to the radiation. The currents on the flap top and the image of the flat top *in the* ground *plane are* in phase opposition and essentially cancel insofar as radiation is concerned, whereas the currents on the vertical part of the radiator and its image are in phase. However, the current on the umbrella wires have a vertical component that is oppositely directed to the current on the tower; therefore, the radiation from the top part of the tower over the distance s and that from the umbrella wires partially cancel.

If there are many umbrella wires, the current on the top part of the tower over the distance s is essentially "screened." Thus, as the length of the umbrella wires is increased, the radiation resistance first increases due to the increased current area on the tower, then it decreases. The maximum in radiation resistance occurs for $s/h = 0.43$ for umbrella antennas operated on frequencies equal to or less than the fundamental frequency of the antenna. For resonant antennas s/h_0 can be adjusted such that the tower height, $h = h_0/\lambda_0$, is resonant at the operating wavelength, λ_0.

While these considerations seem to be fairly straightforward, and, although many measurements have been *made on* short umbrella antennas, insufficient attention was paid to operation at frequencies near the fundamental frequency of the antenna, which is the desirable situation at low and medium frequencies. *The author and a colleague in 1970* therefore decided to make an extensive study of the umbrella antenna by modeling, supplemented by measuring the field radiated from full-size low-frequency antennas. The curves presented here, which have not so far been published, summarize the observational data in a very compact way, make clear the performance of the umbrella antenna, and simplify its design.

fig. 2. Model umbrella antenna above the elevated ground plane ($N = 24, s/h = 0.71$).

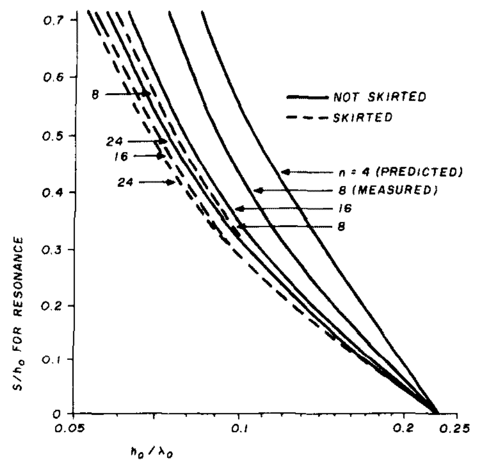

fig. 3. h_0/λ_0 **for resonance versus** s/h_0 **as a function of the number of umbrella wires. Curve for** $n = 4$ **was not measured but was interpolated from observed data.**

experimental setup

The umbrella antenna was modeled as follows. The tower was 1/4-inch (0.6 mm) square aluminum rod 30 inches (76 cm) long. The umbrella wires were No. 24 (0.5 mm) wire. Dimension d/h was fixed and equal to 1.4 (42 inches, or 107 cm for the model). It is clear that d should be as large as possible for maximum top loading, since as d becomes large, the umbrella antenna becomes more like a disk top-loaded radiator. The dimension $d/h = 1.4$ is considered to be a practical design.

The fundamental frequency (for quarter-wave resonance) of the tower *alone* was measured to be 90.6 MHz. That is, the physical length of the monopole was 82.8 degrees. Laport[11] gives $H(\lambda/4) = 84$ *degrees* for a vertical antenna where $h/2a = 107$ (a is the effective radius of the tower).

The model antenna (**fig. 2**) was mounted at the center of a 20-foot (6-meter) diameter hexagonal shaped ground plane, which was elevated so that the impedance measuring equipment, a Hewlett Packard vector impedance meter, model 4815A, could be connected directly to the antenna base from beneath the ground plane. A Hewlett Packard frequency counter, model 5247M, was used so that the frequency could be measured accurately.

Several umbrella antenna configurations were constructed full size and the radiation resistance at low frequency was deduced from field strength measurements. A Stoddard model NM-12AT field-strength meter was used. Field strength measurements were made at eight sites in the distance range 3-22 km so that ground loss and site errors could be accounted for. From these measured field strengths

the radiation resistance, R_r, was determined. Using the appropriate radiation resistance together with the measured model antenna resistance, R_a, the ground loss resistance, R_g, could be estimated. Recall that $R_a = R_r + R_g$.[12] For the model at the frequencies of the measurement, R_g was about 3/4 ohms.

experimental results

Antenna impedances for the model were measured over a range of frequencies up to and above the fundamental frequency of the antenna (2-100 MHz) for a) no top loading, b) various amounts of top loading, $s/h = 0.43, 0.57$ and 0.71; and c) numbers of umbrella wires, $n = 8, 16$, and 24, both skirted and not skirted. Graphs summarizing the results of the measurements are given in **figs. 3** through **6**.

The curves in **fig. 3** give the size of the umbrella hat, as measured by the parameter s/h_o, necessary to resonate the antenna of height h_o/λ_o. That is, h_o is the height of antenna, which together with umbrella top-loading s/h_o, resonates at λ_o. Naturally as the height of the radiator increases, less and less top loading is required for resonance, until $h_o/\tau_o = 0.23$ is reached when the antenna is quarter-wave resonant with no top loading ($s/h_o = 0$). The effect of skirting the umbrella wires can also be seen in this figure, which is equivalent to increasing the number of umbrella wires. According to these data, 8, 16, and 24 wires skirted are approximately equivalent to 21, 33, and 40 umbrella wires without a skirt.

The curves in **fig. 4** show how the radiation resistance, R_r, with top loading adjusted for resonance, increases with decrease in top loading and increase in h; that is, decreases in s/h_o. As expected, when the top loading decreases to zero or $s/h_o = 0$, R_r is the radiation resistance of a quarter-wave monopole, or 35.5 ohms according to our measurements.

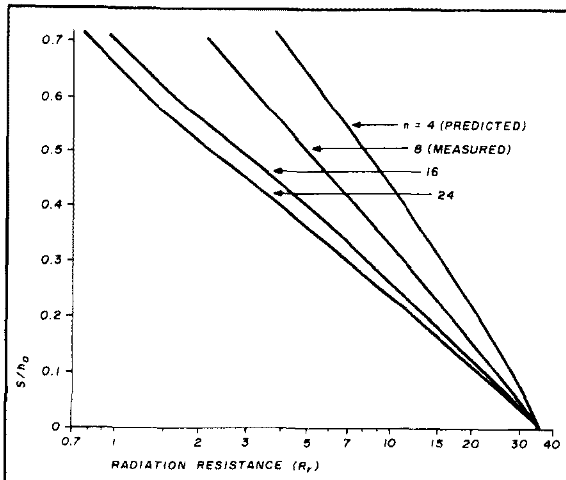

fig. 4. Radiation resistance, R_r, for resonance versus s/h_o as a function of number of umbrella wires. Curve for $n = 4$ was not measured but was interpolated from observed data.

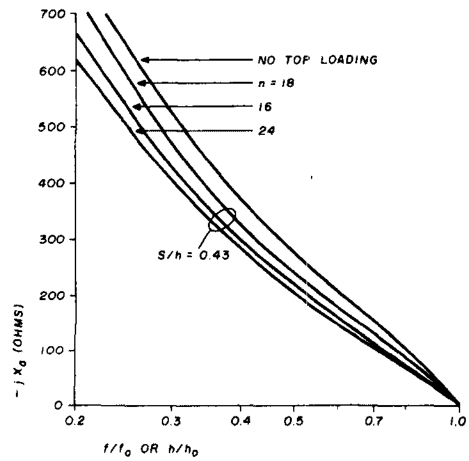

fig. 5. Antenna reactance $-jX_a$ versus f/f_o or h/h_o for antennas shorter than that for resonance.

If the realizable antenna height is shorter than can be resonated with optimum top loading; that is, $s/h_o = 0.43$ (for the case where eight umbrella wires are used), the antenna will be capacitively reactive. The curves in **fig. 5** show how the antenna reactance $-j\ X_a$ increases as the frequency decreases below the resonant frequency, f_o. Since frequency and height scale directly, this graph can also be used to estimate the reactance for an antenna of height h less than h_o for which the antenna is resonant. The graph also gives the reactance for a tower antenna with no top loading ($h/2a = 107$).

The radiation resistance for antenna shorter than that for resonance is calculated according to

$$R_r = R_{r(h_o)} \left(\frac{h}{h_o}\right)^2 \tag{1}$$

where h is the height of the umbrella antenna and h_o is the height required for resonance.

The curves in **fig. 6** show how the antenna Q-factor increases with increase in top loading; that is, with increase in s/h_o. The curves apply to resonant antenna conditions. The antenna Q-factor can be estimated for full-scale antennas where the ground loss resistance is more than 3/4 ohm from the ratio

$$Q_a = Q_{model} \left(\frac{R_{a\,model}}{R_{a\,full\,scale}}\right) \tag{2}$$

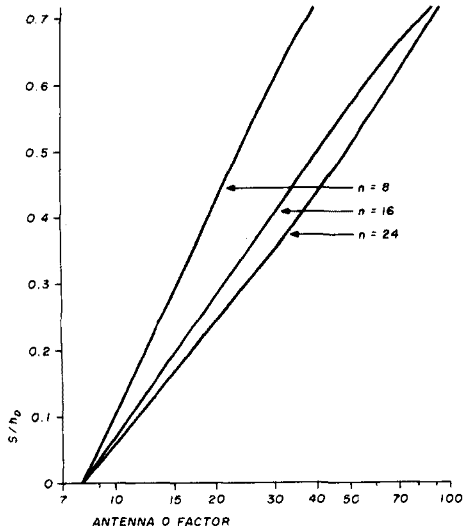

fig. 6. Antenna Q factor, as deduced from the bandwidth of the antenna, versus s/h_o as a function of number of umbrella wires (for resonant antennas).

design examples

Resonant antenna. The following considers the design, step-by-step, for a 160-meter antenna

$$f_o = 1.815\ MHz$$

$$\lambda_o = \frac{984}{1.815} = 542.1\ feet\ (165\ meters)$$

For $s/h = 0.43$, from **fig. 3**, for an antenna employing eight radials

$$h_o/\lambda_o = 0.1$$

or $h_o = 0.1\,(542.1) = 54\ feet\ (16.5\ meters)$

Suppose we choose a tower having a nominal height of 56 feet (17 meters), comprising seven sections 8 feet (2.4 meters) long. If the tower sections overlap by 4.25 inches (11 cm) the actual height is approximately 54 feet (16.5 meters). Since

$$\frac{d}{h} = 1.4$$

$$d = 75.6\ feet\ (23\ meters)$$

According to **fig. 4**, the radiation resistance, R_r is 6.75 ohms. If ground loss resistance R_g is 5 ohms, the radiation efficiency[12] is

$$\eta = \frac{R_r(100)}{R_r + R_g + R_c}$$

$$= \frac{6.75(100)}{6.75 + 5 + 0} = 57\ percent$$

Note that R_c, the coil tuning loss, is zero since the *antenna is resonant.*

The antenna Q factor is given in **fig. 6**, $Q_{model} = 20$, and using **eq. 2**

$$Q_a = \frac{20(7.5)}{11.75} = 12.8$$

and the antenna bandwidth is

$$BW = \frac{2f_o}{Q} = \frac{(2)(1815)}{12.8} = 283\ kHz$$

The factor of 2 accounts for the fact that the antenna bandwidth is *doubled when driven by a transmitter* that is matched to the load.

Folded umbrella antenna. A further simplification can be obtained by folding the vertical element to raise its impedance to the value required by the feeder. The latter may then be connected directly to the antenna without the need for a matching unit. The mast is grounded at the base (see sketch in **fig. 1D**), and a cage of wires surrounds the tower, connected to the top and insulated at the bottom. The feeder is connected directly to the bottom of this cage of wires supporting the mast and a skirt wire joins their ends.

Four or more wires in the cage will be needed. The antenna must first be made self-resonant; that is, the capacitance of the umbrella top must tune with the inductance of the mast and the cage of wires in parallel. This will require slightly more top loading than discussed above. The input impedance (base of mast insulated), which was estimated above to be about 11.75 ohms, will then be raised by about a factor of four to 47 ohms.

Antenna shorter than resonance. To illustrate use of the curves, suppose we design an antenna of height h that is shorter than that required for resonance (h_o). If the height of the tower is, say, 30 feet (9 meters), then

$$\frac{h}{\lambda_o} = \frac{30}{542.1} = 0.055$$

(in metric terms, $\frac{h}{\lambda_o} = \frac{9}{165} = 0.05$)

For eight umbrella wires, and $s/h_o = 0.43$, see above* $h_o/\lambda_o = 0.1$.

Therefore, $h/h_o = \frac{0.055}{0.1} = 0.55$

and, according to **fig. 5**,

$$X_a = -j215\ ohms$$

The radiation resistance is

$$R_r = R_{r(h_o)}\left(\frac{h}{h_o}\right)^2 = 6.75(0.55)^2 = 2\ ohms$$

*We could decide to use longer umbrella wires; that is, $\frac{s}{h_o} > 0.43$ or use more of them.

For a tuning coil Q factor of 300,

$$R_c = \frac{215}{300} = 0.72 \; ohm$$

and the radiation efficiency is

$$\eta = \frac{2(100)}{2 + 5 + 0.72} = 35 \; percent$$

The antenna Q factor is

$$Q = \frac{X_a}{R_a} = \frac{215}{5.72} = 37$$

and the antenna bandwidth is

$$BW = \frac{2f_o}{Q} = \frac{2(1815)}{37} = 96 \; kHz$$

ground-screen requirements

As with all short antennas, a radial wire ground screen must be used to realize high radiation efficiency. For a ground loss resistance of 5 ohms, we estimate, (**fig. 7**) that a ground system of at least ten radial wires would be needed, and these wires should be one-quarter to one-half wavelength long (typically broadcasters employ radial wires 0.412 wavelength long). Note the rather unusual scale in **fig. 7**; this is because $R_g \; \alpha \; \frac{1}{n}$, where n = *number of radials*, and R_g has been plotted versus $\frac{1}{n}$. In fact R_g is inversely proportional to the total length of wire employed in the radial ground screen. The more wire that is buried, the lower the ground loss resistance, but there is little point to increasing the number of radial wires to more than 120 or their length to greater than one-half wavelength.

concluding remarks

Design data have been presented for umbrella-type top-loaded vertical antennas for operation on 160 meters. The various curves are plotted as ratios of the height of the antenna to the wavelength and therefore can be used to design such antennas for any frequency. The 54-foot (16.5-meter) high umbrella antenna at 1.815 MHz would be 26 feet (8 meters) high at 3.8 MHz, 14 feet (4.3 meters) high at 7.2 MHz, and 7 feet (2 meters) high at 14.2 MHz. In addition I have shown how to feed a grounded tower vertical radiator — a method that does not seem to have been used by Radio Amateurs. Shunt-fed or gamma-matched grounded towers have been used, but difficulty has been experienced in exciting a "fat" tower employing a "thin" gamma-match element. Besides, the folded unipole type of feed increases the bandwidth over the conventional base-fed radiator; whereas gamma matching introduces additional reactances (the inductance of the gamma section and the capacitances of the tuning and matching elements), which reduce the bandwidth of the radiator.

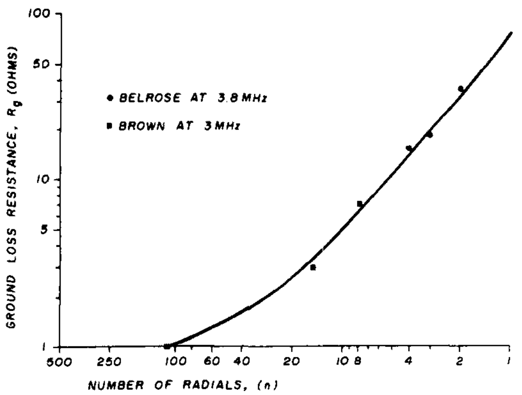

fig. 7. Relationship between ground loss resistance, R_g, and number of radial wires in the ground system. The apparent good agreement between data measured by the author and Brown et al[13] may be coincidental, although both measurements were made over ground of similar conductivity (about 2×10^{-3} mhos/m).

The radiation from the antenna system, of course, requires a return current flow in the tower. Therefore the tower sections must be carefully bonded by jumper straps if the tower is painted, and a good connection to the ground system must be made at the base of the tower. Adequate insulation must be used, especially at the ends of the active guys.

acknowledgments

Thanks are due to Mr. John A. Orosz, formerly of CRC, who meticulously made the model measurements for this study.

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ham radio

efficiency of short antennas

Some unsettling facts about power radiated from short antennas

Because of space limitations, many of us often must use antennas that are shorter than free-space resonant size. This happens, naturally, most often on the lower frequencies, and it's almost a universal practice in high-frequency mobile installations. How efficient are these antennas? That depends on many things, but there are ways to measure the efficiency of your antenna. In this article, we will examine the resistance method of determining antenna efficiency. You might be surprised at the results of such a test on your antenna system.

antenna or antenna system?

We can speak of the efficiency of the antenna itself, or we can speak of the efficiency of the entire antenna system. The latter includes not only the actual radiator, but also the feed line, the transmatch (if any), and the transmitter tank circuit components. In either case, *efficiency* refers to that percentage of the applied power that is actually radiated into space.

For our purposes, when speaking of efficiency, we will be talking about the efficiency of the antenna only. Losses may occur in the antenna conductors, splices in the conductors, loading coils, or the surrounding earth and terrain in general. The object, of course, is to minimize such losses.

radiation resistance

Once an antenna radiates energy, that energy is gone forever: it never comes back. When a resistor dissipates energy, that is also gone forever; in fact, to a transmitting system, radiation is just the same as dissipation. Radiation of energy by an antenna appears to occur across certain values of resistance.

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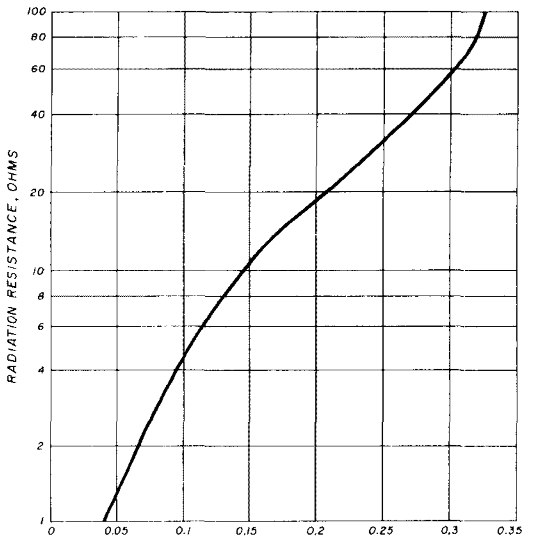

fig. 1. Radiation resistance of a vertical antenna in terms of its height in wavelengths. This graph is valid only for antennas without parasitic or phased elements.

Replacing an antenna with the correct value of resistor allows the transmitting system to perform normally, and in precisely the same way it would with the antenna. The value of this resistance depends on certain characteristics of the antenna, but it is primarily a function of the physical size of the antenna. This property is called the radiation resistance.

For vertical antennas, the radiation resistance is a direct function of the height in wavelengths. **Fig. 1** illustrates this function. For a center-fed antenna in free space, the radiation resistance versus length is shown in **fig. 2**. A dipole (center-fed) antenna acts like two vertical antennas operating in series; note that a dipole whose overall length is x wavelength has twice the radiation resistance of a vertical whose height is x/2 wavelength.

reactance

An antenna is resonant if and only if there is no reactance at the operating frequency. Although resonance is a desirable condition from the standpoint of impedance matching, it is not necessary. Many antennas are not resonant yet still function well. The antenna *system*, however, should always be resonant at the operating frequency in order for the transmitter to deliver the maximum energy into it.

When a vertical antenna is physically shorter than 1/4 wavelength in free space, or a dipole is shorter than 1/2 wavelength, it is necessary to put loading coils in series with the radiator in order to obtain resonance. The shorter the antenna is at a given frequency, the larger the inductor must be.* It is possible, theoretically, to make an antenna resonant no matter how short it is.

When a vertical antenna is physically longer than 1/4 wavelength, or a dipole is longer than 1/2 wavelength, it is necessary to use series capacitors to get resonance. This can be done up to any length.

In both of the above-mentioned cases, the coils and capacitors serve to get rid of the reactance in the antenna system. A short antenna is capacitively reactive and needs an inductor to cancel the reactance; a long antenna is inductively reactive and requires a capacitor to cancel the reactance. Short antennas are far more common than long ones, and thus inductive loading is seen much more often than capacitive loading.

Unfortunately, coils always have a certain amount of loss resistance. When we use an inductor in a short antenna to get rid of the reactance, we are left with a pure resistance. But this resistance is not just radiation resistance; some of it is loss caused by the coil. And of course, all the other loss resistances, such as conductor and earth losses, are still in the cir-

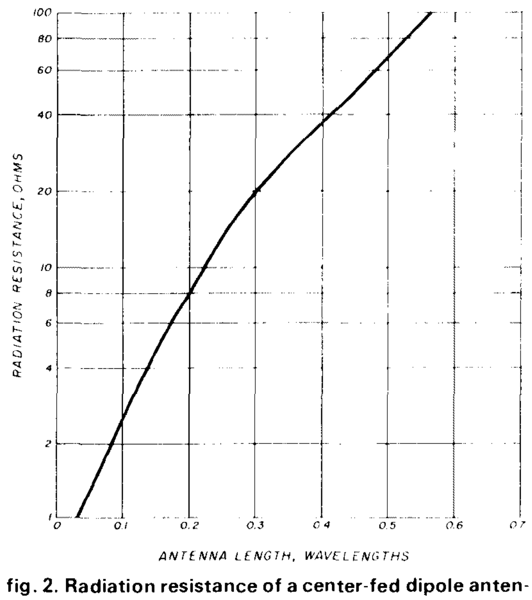

fig. 2. Radiation resistance of a center-fed dipole antenna in terms of its overall length in wavelengths. This graph is valid only for antennas without parasitic or phased elements.

*That is, for a given inductor position in the radiating element. For a given antenna length and frequency, the amount of inductance required gets larger as the coil is moved toward the end of the radiator.

cuit. The pure resistance consists of two components, then: the radiation resistance, denoted by R_R, and the loss resistance, denoted by R_L.

loss resistance

The total resistance of the antenna is

$$R_T = R_R + R_L$$

because R_R and R_L are effectively in series. The value of R_R is a function of the physical length of the antenna, and is thus a constant for a given antenna. Loss resistance, R_L, is a variable; it can be minimized by using a radial or ground screen system, large-diameter conductors, low-loss coils, and the like. Of course, the objective is to minimize R_L.

At resonance, the impedance of the antenna is purely resistive, and has a value of R_T. If the line has a characteristic impedance of Z_0, then

$$SWR = Z_0/R_T \text{ if } Z_0 \geq R_T, \text{ and}$$
$$SWR = R_T/Z_0 \text{ if } Z_0 \leq R_T$$

Oddly enough, it is often true that the higher the efficiency of the antenna, the higher the SWR. Quite often, a low SWR with a short antenna is an indicator of terrible efficiency! This is because as we minimize R_L, we also minimize R_T, which may already be much smaller than the line Z_0.

efficiency

To measure the efficiency of an antenna directly, it would be necessary to use instruments that few hams have, and the process would be extremely time-consuming. However, we can get a very close approximation of the efficiency of an antenna by simply measuring its resistance at resonance. To do this, you need an impedance bridge.* Obtaining R_T in this way, and knowing R_R from **fig. 1** or **fig. 2**, the efficiency of the antenna is approximately

$$efficiency\ (percent) = 100\, R_R/R_T$$

Only the energy delivered to R_R, the radiation resistance, is radiated; that delivered to R_L is lost. The loss resistance is concentrated mainly in the loading coil and the earth near the antenna. Sometimes we cannot install a ground radial system — for example, in a mobile installation. We can make the coil only so big before it gets excessively bulky. Thus, the efficiency of a short antenna is limited by practical considerations.

no impedance bridge?

You most probably have an SWR meter, but chances are you do not have an impedance bridge. You can still measure the efficiency of a short antenna, in most cases, using only an SWR indicator, because it is much more likely that $R_T \leq Z_0$, when the antenna is short, than vice-versa. (There is a limit to how lossy even the worst installation can be!) Thus

$$SWR = Z_0/R_T;\ R_T = Z_0/SWR.$$

Determining R_R from **fig. 1** or **fig. 2**, we can calculate the efficiency as before.

For longer antennas (verticals over 1/4 wavelength high or dipoles longer than 1/2 wavelength), it is quite possible that R_T will be larger than the line Z_0. Unfortunately, using just an SWR meter, we have no way of knowing whether R_T is larger or smaller than Z_0, except by using intuition. So it is definitely best to use an impedance bridge, if possible, for measuring efficiency. The impedance bridge or SWR meter should, of course, be placed at the point where the line feeds the antenna. Placing the instrument at any other point will cause false readings.*

practical examples

Suppose we have a 40-meter vertical, ground-mounted, and 14 feet (4.3 meters) high with a loading coil at the center, as shown in **fig. 3**. We have managed to install several radials, and measure the SWR at the feed point as 1.0 at resonance. (Resonance is indicated by the frequency where the SWR is minimum, for all practical purposes.)

At 7 MHz, a free-space wavelength is given by

$$length\ (feet) = 984/7 = 140.6, \text{ or}$$
$$length\ (meters) = 300/7 = 43$$

and thus 14 feet (4.3 meters) represents about 0.1 wavelength. From **fig. 1**, the value of the radiation resistance, R_R, is approximately 4 ohms.

Since the SWR is 1.0, the value of R_T must be equal to the line impedance, which is 50 ohms. Consequently,

$$efficiency\ (percent) = 100 \times 4/50 = 8$$

That's correct. Eight percent!

If the antenna were one-hundred percent efficient, R_T would be equal to R_R, which is 4 ohms. Then the SWR would be 50/4, or 12.5!

To illustrate another example, suppose we have a 75-meter mobile antenna that displays an SWR of 2 at resonance, using no matching transformers of any kind. If this antenna is 8 feet (2.4 meters) high at 3.875 MHz, it is a paltry 0.03 wavelength high. In **fig. 1**,

*An impedance bridge is a more sophisticated device than the common SWR bridge. An impedance bridge shows the values of reactance and radiation resistance in an antenna system.

*If an SWR meter is used, the SWR seems to get smaller (closer to 1) as the instrument is moved away from the antenna. If an impedance bridge is used, reactance will be introduced when the instrument is not at the feed point, unless the match happens to be perfect ($R_T = Z_0$).

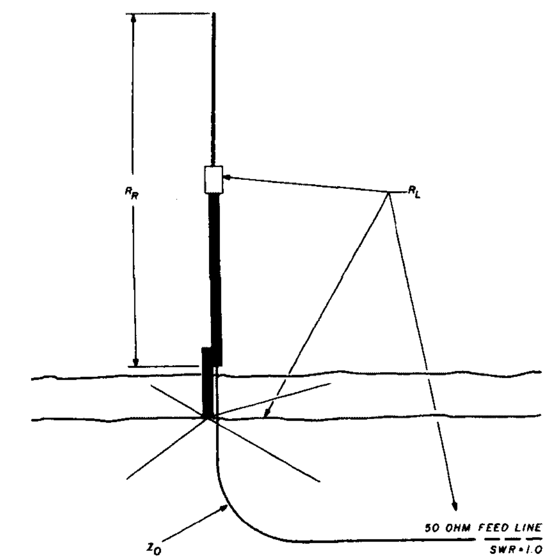

fig. 3. A 7-MHz, 14-foot vertical antenna. Here, R_R is about 4 ohms, and R_L is equal to the difference between Z_0 and R_R, or 46 ohms. This antenna has an efficiency of eight percent if the SWR is equal to 1.

that is just about off the chart; R_R is roughly 1 ohm.

Since the SWR is 2, we may assume that $R_T = 50/2 = 25$. So

$$efficiency\ (percent) = 100 \times 1/25 = 4$$

It is possible (though not likely) that R_T is twice Z_0, or 100 ohms; then

$$efficiency\ (percent) = 100 \times 1/100 = 1$$

We would need an impedance bridge to be certain.

conclusion

These results may, in fact should be, unsettling. Short antennas generally are not efficient ones. This is especially true for vertical antennas over less-than-perfect conducting ground.

If a short antenna is made highly efficient by minimizing R_L, it is inevitable that the SWR will be high at resonance. This, however, can be alleviated by using matching networks. If the feed line is short, the matching network can be placed at the transmitter for convenience, since the SWR loss will be rather small in a short run of cable. If the feed line is long or the SWR is extremely high, you would do better to put the matching device at the antenna feed point. Broadbanded matching transformers are available for this purpose.

ham radio

DIGITAL TECHNIQUES

Digital techniques: inside a phase-frequency detector

Widespread use of phase-lock techniques for Amateur frequency control has increased digital circuitry in receivers and transmitters. The heart of a phase-locked loop (PLL) is the phase detector and this article examines one specific device: The Motorola MC4044 phase-frequency detector.

Each PLL should have a phase detector with linear phase response greater than ± 180 degrees and, for lock-in purposes, hold at maximum or minimum output until the controlled frequency comes within phase of the reference. The phase-frequency detector digital section of the MC4044 in **fig. 1** does this well. The gate arrangement allows it to be duplicated by three conventional gate packages.[1] The circuit can be duplicated in any digital family.

The MC4044 has TTL input/output and includes a "charge pump," or time-to-capacitor-charge converter. Digital output is a pulse width proportional to phase so a summing integrator can substitute for the charge pump. Either is part of the loop filter block in **fig. 2A**. Transfer characteristics of both phase detector and loop filter are shown in **fig. 2B**. Emphasis will be on the digital portion.

inputs, outputs and the stable state

Gate identification is arbitrarily alphabetical since only NAND gates are involved. Reference frequency is designated R and VCO or divided VCO input is S for signal. Phase detection takes place *only on negative-going transitions* of R and S.

Phase-proportional output is the *low* state time of gate B ($\overline{\text{LAG}}$) or gate D ($\overline{\text{LEAD}}$). Lead and lag is defined as S phase relative to reference R. Gate arrangement symmetry requires the output designations positioned relative to the particular inputs.

Gate states are stable when both inputs are high, or Logic 1, and gates A, C, F, and H are low, or Logic 0. This can be seen in the time-start of timing diagram in **fig. 3**. Outputs (gates B and D) will remain high; no phase has been detected at time-start.

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If the stable condition seems confusing, work it out on scratch paper using the "NAND Rule" given in previous articles of this series: Any low input will make the output high; all inputs must be high to make the output low.[2]

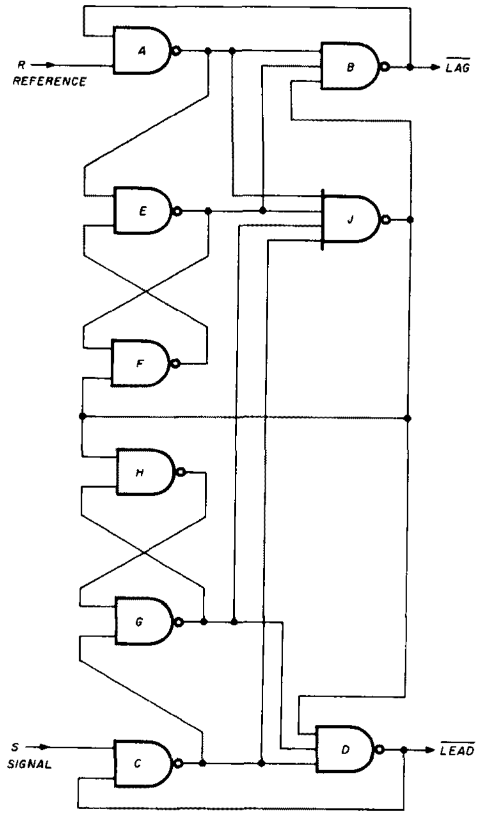

fig. 1. NAND gate array of the Motorola MC4344/ MC4044 phase-frequency detector, digital section only. See text and timing diagrams for gate identification.

a rather complex flip-flop

The amount of gate feedback requires "walking through" the circuit in time, always remembering that every gate takes a finite amount of time to change state (propagation delay). **Fig. 3** is used for starters with an assumed signal lag. It should be noted that all timing diagrams have exaggerated gate delays for illustration only.

Reference R goes low. Gate A output goes high from the NAND Rule. Gate B goes low since all its inputs are now high and this reinforces holding A low. Gate E doesn't change since it was already held high by F.

Signal S now drops low, C goes high, then D goes low, all similar to R, A, and B. The difference is that all inputs of gate J are now high; E and G were stable

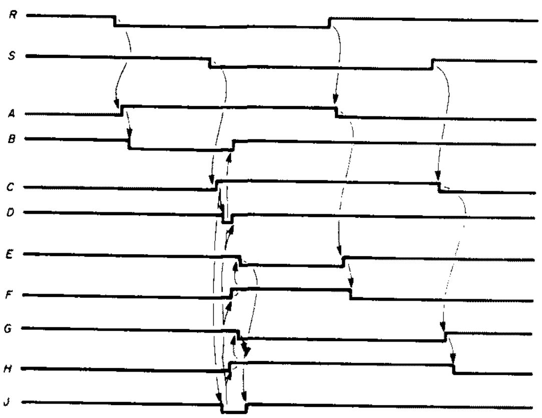

fig. 3. Timing diagram of phase-frequency detector with signal lagging reference. Gate propagation delays are exaggerated. Arrows indicate gate state changes affecting other gates.

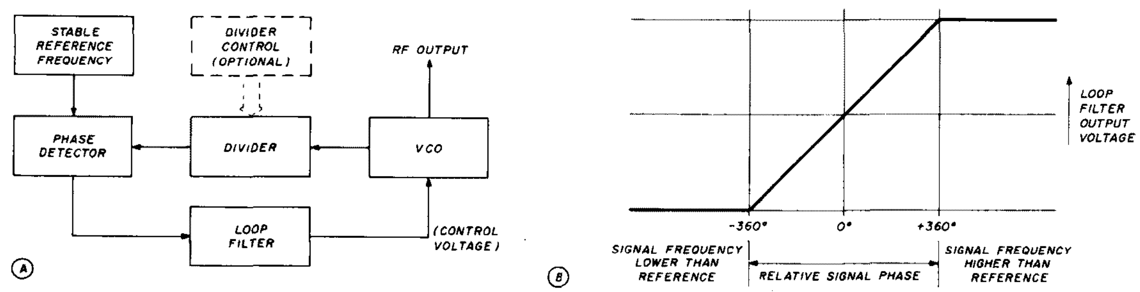

fig. 2. General block diagram of a phase-locked loop (A). Transfer characteristic of a phase-frequency detector is shown in (B).

high, A went high from R, then C went high. Gate J goes low and forces a sequence: Both B and D are made high (D remains low only for the gate delay of J), F and H are forced high.

Gate E must go low since inputs from A and F are both high. Gate G also goes low from C and H. Gate J is reset low from E and G even though A and C are still high. J has remained low for only three gate delays.

Set-reset flip-flops E and F, G and H are required for the intermediate time-state until either R or S return high. When R goes high, A goes low to hold B high. B was forced high due to the input from gate E being low. E will now go high but doesn't change B; the A change occurred first. Gate F returns to its stable low state since all inputs are high.

Returning S high will change, in order: C, G, and H in the same manner as A, E, and F. An important note is that all gate propagation delays are approximately the same so that the time-state changes occur in proper sequence.

$\overline{\text{LAG}}$ output is low only for the time difference (phase) of R and S negative transitions. It is low for one extra gate delay but a summing integrator will cancel this via the $\overline{\text{LEAD}}$ short low state. Any lag will have the same short low state of $\overline{\text{LEAD}}$ plus the extra gate delay time of $\overline{\text{LAG}}$.

short input times and maximum speed

The timing diagram of **fig. 4** has a lagging signal input but both inputs are short and do not overlap.

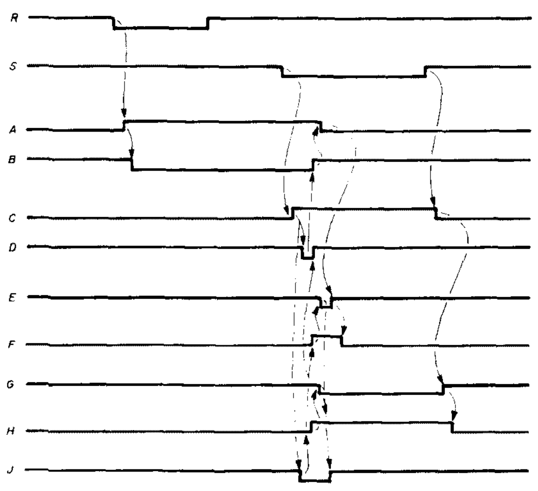

fig. 4. Same conditions as in *fig. 3* except reference R and signal S inputs are not overlapping. Note change in intermediate latch, gates E and F.

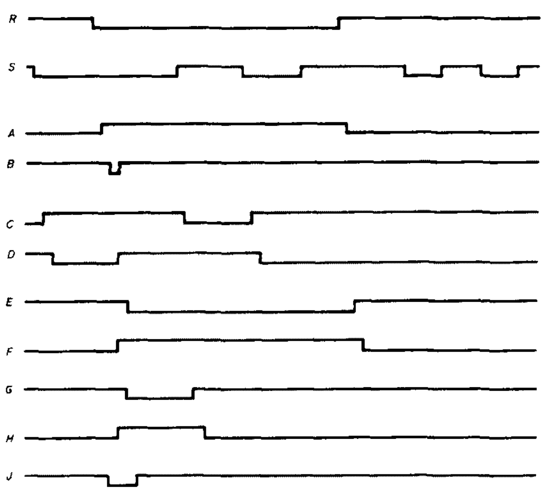

fig. 5. Timing diagram when signal frequency becomes higher than reference.

Gates A and B behave as in **fig. 3**. The difference occurs in the duration of intermediate flip-flop gates E and F.

When gate B is made high by a low J, A goes low since R was high before the negative edge of S. Gate F was forced high by a low J but E would go low due to A still being high. Gate A then drops low to force E high again. E is low for only one gate delay. Gate F resets since J has returned high by way of E and G going low.

The stable state is restored as in **fig. 3** when the positive-going edge of S occurs. The $\overline{\text{LAG}}$ output still represents the time difference between negative-going transitions of R and S.

The minimum low-state time of R or S is approximately 7 gate delays including the reset time on the positive edge of S. Maximum operating speed is inversely proportional to about 9 gate delays — about 6 MHz at 18 nanoseconds per gate.

letting the signal run faster

Fig. 5 shows an S input leading R, then increasing in frequency. There is a momentary low state of $\overline{\text{LEAD}}$ (gate D) followed by a *one-gate* delay of $\overline{\text{LAG}}$ (gate B). Thereafter, $\overline{\text{LEAD}}$ will remain low until the next negative-going edge of R. Transfer characteristics of **fig. 2B** will be satisfied if both detector outputs are averaged.

In-phase maximum output extends very near to ±360 degrees. The phase-frequency detector would make an excellent, wide-range phase meter when preceded by input comparators and followed by an integrator and analog voltmeter.

question sure to be asked

Fig. 6 shows timing at an absolutely in-phase time situation. No race condition exists and both outputs will go low for only one gate delay; summed outputs are zero. Any nonzero output is due to propagation delay differences between gates B and D, a nanosecond or two.

This timing diagram illustrates the symmetry of the gate arrangement. Inputs and outputs may be interchanged without affecting operation.

The stable state may not exist on power-up. I checked all 2048 combinations on nine gates and two inputs on an Apple II program for automatic settling. Forty combinations do not settle immediately but all will settle on the first arrival of a reference or signal input.

creating an analog output

A Motorola chip can use the on-board charge pump. The reader is referred to Motorola literature for connections and values.[3]

Greater flexibility is possible with separate op-amp integrators and filters. A summing integrator is given in **fig. 7**. Open-collector gates are assumed for B and D. The difference in collector return and integrator input resistor value ratios minimize op-amp offset bias; ratios are not absolute.

This integrator is an active lowpass filter with 6 dB per octave (20 dB/decade) high frequency response. The −3 dB frequency (F_c) is found by:

$$F_c = \frac{1}{2\pi R_2 C}$$

Dc voltage gain is simply R2/R1. Low-frequency gain must recognize that Logic 0 is not zero volts; TTL swings +0.3 to supply voltage with open-collector outputs.

Assuming all resistors are 10 k and C is 0.33 μF, dc gain is unity and the −3 dB corner frequency is 48.2 Hz. Voltage gain is −26 dB at 1 kHz.

Many variations are possible in the PLL's analog portion. Texts in the bibliography are suggested for the serious experimenter.

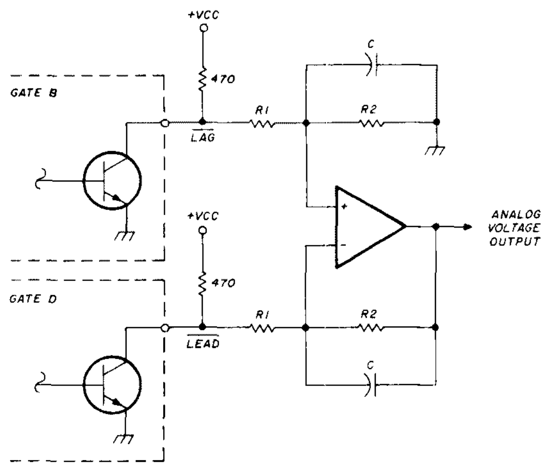

fig. 7. A simple summing integrator with open-collector gates B and D. Conventional totem-pole gate outputs useable with allowance of changes in high-state voltage.

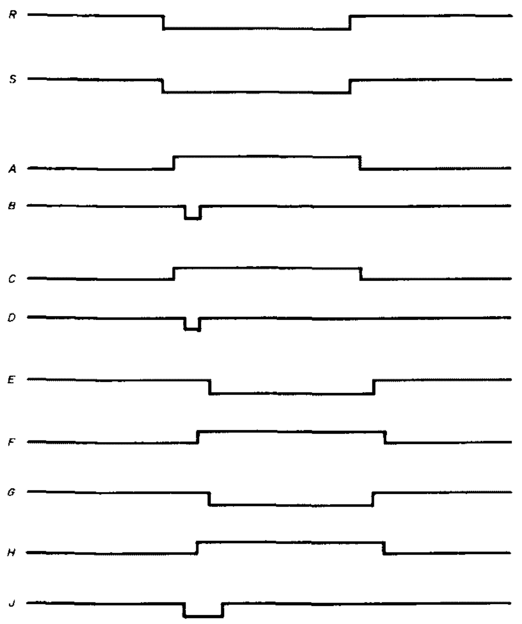

fig. 6. Timing when both reference and signal inputs are exactly in phase. Time symmetry reflects gate arrangement.

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ham radio

the ultimate tone decoder

A simple circuit that keeps your autopatch from hanging up on you

If your autopatch has developed some obnoxious habits, such as interrupting your 2-meter conversations with random dial tones or rudely ending your autopatch calls, then this decoder circuit is for you. The phase-lock-loop system used on many autopatch decoders works well for strong signals or signals that are precisely tuned to frequency. When a weak signal or one that is slightly off frequency is encountered, however, the phase-lock-loop decoder tends to false, which results in noise being received as a tone, and tones being rejected as a noise. One cure for a mischievous tone decoder is to require a long delay in activating or dropping the autopatch. A better cure is this state-of-the-art system that uses two new integrated circuits from Mitel.

The system is built around the Mitel 8860 and 8865 DTMF decoder and filter ICs. These chips, introduced in August, 1980, feature high-quality detection, excellent voice and noise rejection, crystal controlled accuracy, and rapid detection time. They are low-power CMOS chips, requiring only about 30 mW apiece. The system will provide a 30 dB dynamic range; in other words, the range of audio levels that it will accept is -30 dB to 0 dB. This wide tolerance of tones means that the user's Touchtone pad audio level is not extremely critical, the way it is with some phase-lock-loop decoding systems. The maximum tone frequency deviation is ± 2.5 percent, compared with the general standard in the telephone industry of ± 1.5 percent.

This circuit will provide either binary or digit-by-digit output. The binary lines are tri-state, which means that the decoder can be connected directly into the data bus of your computer-controlled repeater. The sixteen-line digit-by-digit output can connect to a repeater control that requires a line for each tone decoded. Although many repeaters use only the twelve standard Touchtone pairs, the Mitel chip is able to decode all sixteen pairs.

a case history

The decoder system shown in the schematic has been installed and tested on K9ORU/R, located in Belvidere, Illinois. The repeater formerly used a phase-lock-loop tone decoder, which falsed frequently. Several types of filters and AGC amplifiers were used in trying to correct this problem, but none of them met with much success. Setting a long delay on the auto-patch code ended the falsing, but required users to hold their Touchtone pad buttons down for several seconds to access the auto-patch. Because the long delay wasted air time, and because that decoder had numerous other minor problems, the group looked for an entirely new decoder system. Their research pointed to the Mitel dual-tone multi-frequency (DTMF) chips as the ideal solution, and the circuit described in the schematic was designed around those chips.

The new decoder system cost the K9ORU members about $65.00 to build and install, using primarily new parts. The Mitel chips themselves cost almost $50.00, and $15.00 was spent on other parts, including an aluminum box to house the circuit.

Since this decoder was installed, in early 1981, there has been no falsing of the repeater. The need for a long delay before accessing the autopatch was eliminated, as were all of the minor problems that had afflicted the system. Because the new decoder doesn't need such critical settings of tone frequency, every member's phone pad is able to activate the au-

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topatch. All phone calls into the repeater for control purposes have worked, from every phone that's been tried. And the microprocessor-controlled automatic dialers used by some of the repeater members can no longer out-dial the decoder.

circuit description

This circuit uses a total of six integrated circuits: one MT8865 DTMF filter; one MT8860 DTMF decoder; one 74154 four-to-sixteen line decoder, and three 7404 inverters, two of which are optional. (Omit the optional 7404s and the sixteen-line output will be normally high, active low.)

Our circuit was constructed on a 2½ × 5 inch perf-board and housed in an aluminum utility box. We connected it to our existing repeater control through ribbon cable and dip-headers.

Referring to **fig. 1**, audio from the receiver is brought into the 8865 filter pin 4 through an 0.015-mF capacitor. This chip is a six-pole bandpass filter that rejects noise, voice, and dial tones, and separates the high and low tone groups. Frequency reference is provided by an internal oscillator in the 8865 that is controlled by an inexpensive 3.5-MHz TV colorburst crystal. This oscillator also provides frequency reference for the 8860 decoder. The high group tones are brought out on pin 10 and the low group tones are brought out on pin 1. They are fed into the 8860 decoder on pins 4 and 13 respectively.

The 8860 performs the actual decoding of the DTMF pairs. Pin 15 of the 8860 provides a logic high whenever a valid tone pair is being received. This output is buffered by a 7404 inverter. It is used to strobe the sixteen-line decoder and to illuminate the

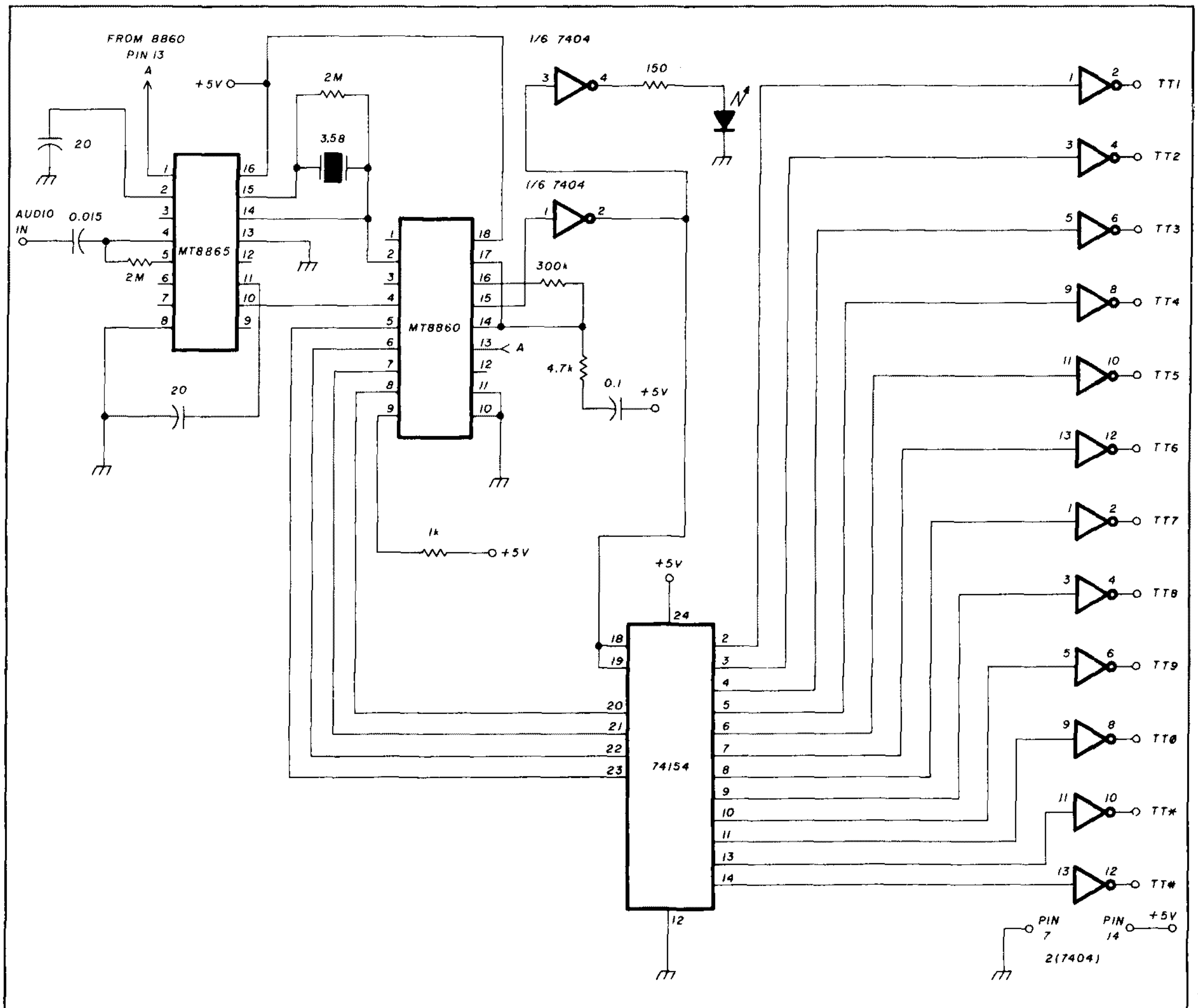

fig. 1. Schematic for the DTMF decoder.

valid tone LED. This LED is placed on the board and is used for diagnostic purposes. The strobe is necessary because the binary lines are latched, and the desired output should present a 1 while the tone is being received. Pin 9 is the output control line. When pulled low, the outputs are put in their high-impedance state. This feature may be used if you are connecting the decoder directly to a computer, but in this instance, we simply tie the line to a logic high through a 1K resistor. Pins 5, 6, 7, and 8 are the binary output lines, which are connected to the binary input line of the 74154. This IC simply decodes the binary number from the 8860 to a single line output of each Touchtone pair.

When the 74154 is enabled by a valid tone signal, it presents a logic low at the output corresponding to the specific tone pair decoded. This low is then inverted by a section of a 7404 to provide an active high signal.

Shown in the schematic are inverters for the twelve standard Touchtone pairs. The four remaining sections of the 7404 used in the valid tone signal circuit may be connected to the 74154 to provide Touchtone pairs A, B, C, and D if desired. The inverters may be left off if an active low is desired.

The entire circuit is powered by a single 5-volt supply.

testing

Apply 5 volts to the unit and connect the audio input to a source of Touchtone signals, either your receiver or a telephone or Touchtone pad. Depress a button on the Touchtone pad. The valid tone LED should light up and the corresponding output should switch to a logic high (approximately 5 volts). Release the button and the light should go out and the output should go to 0 volts. Repeat the procedure for the remaining Touchtone pairs. If you have difficulty, the high and low tone outputs can be monitored at pins 10 and 1 of the DTMF filter using a pair of high-impedance headphones connected through a 0.1-mF capacitor.

final comments

This circuit can easily be built into a new control right on board, or it can be wired into an existing control as we did. If the unit will be located more than 6 inches away from the power supply, the supply leads should be bypassed with a small capacitor to prevent rf pickup. If the output leads will be more than 6 inches long, they too should be bypassed.

Once you put this control into operation, you can expect many years of trouble-free operation. And your autopatch won't hang up on you ever again.

ham radio

the K7CW quad

A full-size Quad that's lightweight and inexpensive

Shortly after my first antenna article was published[1] I received my degree in geological sciences and took a job that meant moving to Brazil, where I held the call PP6ZAA. As soon as I received my license I got on the air using a borrowed FT-101 and dipole antennas. The responses I could generate with my unusual prefix were many, but I got into a couple of contests and did miserably. My 100 watts and dipoles were just no competition for those hams using gain antennas.

I decided a change in antennas was necessary, and, having been a quad fan ever since my Novice days, I knew what my choice would be. Because my job requires a lot of moving around, I had to have a quad that was light in weight, and easily assembled and disassembled.

I like the delta-loop-type quad mainly because it mounts in such a way that the entire antenna is above the supporting structure. On the other hand, the traditional square or diamond quad has easy-to-feed wire elements and is not "top-heavy." Both of these two quads, however, are wind-catching rotator damagers.

What I have designed is an antenna that combines the favorable qualities of these two quads. The antenna has two wire loops in the inverted-delta configuration, and it is fed at the bottom of the driven element in the classic wire-quad fashion (break the loop and connect the coax). See **fig. 1**. There are four main spreaders but no boom, and there is an additional bottom spreader which has no major support function. The bottom spreader can be made of very lightweight material because its only functions are to keep the bottoms of the loops in proper position with respect to the rest of the antenna and to support the coax to the driven element.

The four main spreaders are attached to a main spreader hub by means of U bolts. The main hub is bolted to a bracket which, in turn, is U bolted to the mast. The antenna is designed to have 0.2λ spacing between the elements. The bottom spreader is, thus, 0.2λ long.

The reflector loop is connected, on top, to the tips of the two rear main spreaders and to the tip of the rear of the bottom spreader. The loop wire will form an equilateral triangle.

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table 1. *Formulas used to obtain proper dimensions of the antenna as labeled in fig. 1.*

formulas	notes
$X = \dfrac{1030}{9.84F}$	Where F = design frequency of antenna (3X = total distance around reflector loop).
$A = \dfrac{1005}{9.84F}$	3A = total distance around driven element loop.
$H = \dfrac{X}{2}$	= distance from main hub to top of antenna (the imaginary plane which contains the tips of all four spreaders).
$D = .2\lambda$	where λ = wavelength at design frequency. D = element spacing = length of bottom spreader.
$E = \sqrt{X_2 - H^2} - H$	= distance from bottom spreader to main hub.
$C = \sqrt{2H^2 + \left(\dfrac{D}{2}\right)^2}$	= distance from hub to where loop is attached to main spreader.

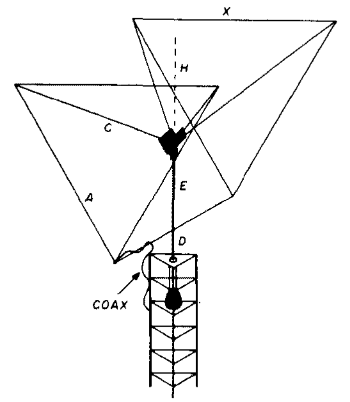

fig. 1. The K7CW quad.

The driven element loop does not form an exact equilateral triangle because of the fact that it is also connected to the bottom spreader (which is horizontal with respect to the ground) and is smaller in size than the reflector. So a little shifting of position of the loop on the spreaders is called for (otherwise the bottom spreader can be tilted to conform, but this will disrupt the visual symmetry of the quad).

A list of formulas for obtaining proper dimensions of the antenna is given in **table 1**. If you follow the table, you will be able to construct the antenna for any frequency. In order to save you time, however, I have done the necessary calculations for frequencies in all the Amateur bands, 80 through 6 meters. These dimensions are found in **table 2**.

The main spreader hub was designed to be simple. It consists of two parts, the hub itself and a bracket which is used to mount the hub to the mast. See **fig. 2**. The hub is fashioned from an 18 × 10 inch (45.72 × 25.4 cm) piece of 3/16-inch (4.76-mm) aluminum sheet. Steel may be used, but I discourage its use because it defeats the purpose of trying to build a lightweight antenna. Before the pieces are bent to form the indicated angles, holes for the mounting bolts and U bolts should be drilled. Locations of the bolt holes for mounting the bracket to the hub are marked. However, each builder must determine for himself the exact locations of the U bolt holes to fit his particular needs with respect to diameter of spreaders and mast (that is, U bolt sizes). Center lines have been drawn on **figs. 3** and **4** to show approximate loca-

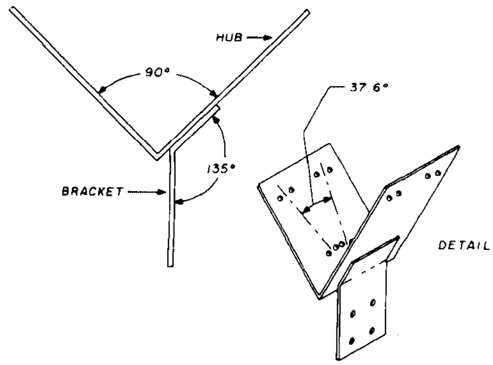

fig. 2. Main spreader hub and mounting bracket.

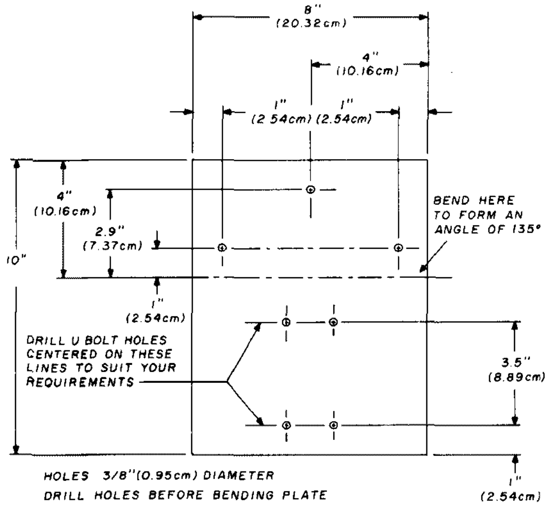

fig. 3. Reduced template, main hub to mast bracket.

tions of the U bolts. It is important to note that the axes of the spreaders must lie on the lines indicated in **fig. 4**.

An interesting sidelight appeared to me as I designed the antenna. The fact that I assigned (arbitrarily) the distance from the hub to the top of the antenna to be equal to the loop circumference divided by six, (or H = x/2), resulted in an arrangement that would readily allow the addition of other loops for different bands, with proper spacing, simply by the addition of another bottom spreader per band. See **fig. 5** and **6**. One need only use the formulas in **table 1** to determine the proper lengths and locations of the loops within the main structure.

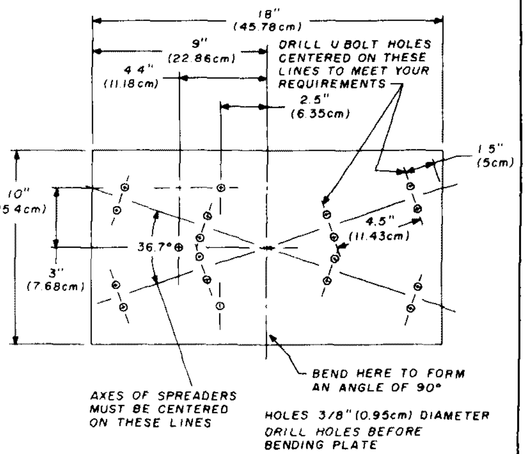

fig. 4. Reduced template, main spreader hub.

Undoubtedly, it's already occurred to many readers that the antenna could be turned upside down to obtain better weight distribution of the antenna on the tower. See **fig. 7**. A description of this principle is made by Myers.[2] At first, it never occurred to me to do this because I'd wanted to get the whole antenna above the tower. However, it seems to me that one could build, say, a 40-meter version of my antenna, invert it on the tower and have a lightweight, low-torque, inexpensive beam with reasonable gain for 7 MHz. The builder might have to beef up the hub somewhat.

The kind of hub I have already described would work well. In this case it could be made of steel. The only modification needed would be to include a hole a bit larger than the mast diameter in the sheet metal before it is bent. Then, rather than having the hub sit on top of the mast, the mast would pass through the hub to be bolted to the bracket above the hub. Now, obviously, 99.99 percent of us won't be able to con-

table 2. K7CW quad dimensions.

antenna design frequencies (in meters)

	3.575 MHz	3.8 MHz	7.05 MHz	7.2 MHz	14.075 MHz	14.25 MHz	21.1 MHz
X	29.2722	27.5389	14.8437	14.5344	7.43503	7.34372	4.95962
Y	87.8165	82.6168	44.5311	43.6033	22.3051	22.0312	14.8789
A	28.5617	26.8705	14.4834	14.1817	7.25457	7.16547	4.83924
B	85.685	80.6116	43.4502	42.5450	21.7637	21.4964	14.5177
H	14.6361	13.7695	7.42184	7.26722	3.71751	3.67186	2.47981
D	16.7832	15.7895	8.51064	8.33333	4.26288	4.21053	2.84360
E	10.7144	10.0800	5.43317	5.31998	2.72141	2.68799	1.81535
C	22.3349	21.0124	11.3258	11.0899	5.67298	5.60331	3.78423

	21.3 MHz	28.15 MHz	28.6 MHz	29 MHz	50.05 MHz	50.125 MHz	53 MHz
X	4.91305	3.71751	3.63902	3.60855	2.09087	2.08774	1.97449
Y	14.7392	11.1525	10.9771	10.8257	6.27261	6.26322	5.92347
A	4.79380	3.62728	3.57021	3.52097	2.04012	2.03707	1.92657
B	14.3814	10.8818	10.7106	10.5629	6.12036	6.11120	5.77970
H	2.45653	1.85876	1.82951	1.80428	1.04543	1.04387	.987245
D	2.81690	2.13144	2.09790	2.06897	1.19880	1.19701	1.13208
E	1.79830	1.36070	1.33929	1.32082	.765311	.764166	.722714
C	3.74870	2.83649	2.79186	2.75335	1.59535	1.59296	1.50655

Note: X = length of reflector loop side
Y = distance around reflector loop
A = length of driven element loop side
B = total distance around driven element loop
H = distance from hub to top of antenna
D = bottom spreader length
~ element spacing
E = distance from bottom spreader to main hub
C = distance from hub to where loop is attached to main spreader, that is, spreader length

struct an 80-meter version, but go-getters who have lots of room can — and I challenge them to try it. The mechanical problems involved in building a full-size rotatable 80-meter beam are numerous, but I personally helped put a full-size two-element 80-meter beam on top of a 170-foot (51.8-meter) tower, so I know it can be done.

I used bamboo for the spreaders on the first version of the antenna because fiberglass is hard to get in Brazil. Bamboo works well. However, fiberglass would appear to be the best choice for spreader material.

I won't go into a lecture on how well my quad works. Everyone knows how good quads are. Let me tell you, though, about the advantages of having an antenna with no boom. Since there is no boom, there is a marked reduction in rotational torque applied to the rotator (caused by wind loading or sudden starts and stops). There can be no appreciable amount of damage to the rotator due to torque because everything on the antenna is flexible. There are, in fact, a lot of advantages to the antenna. Let's go over them.

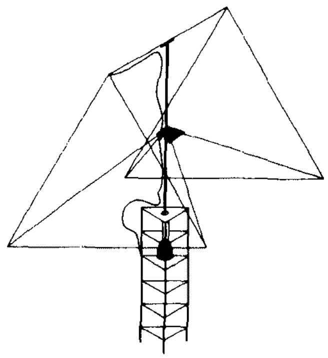

fig. 7. Variation of the quad.

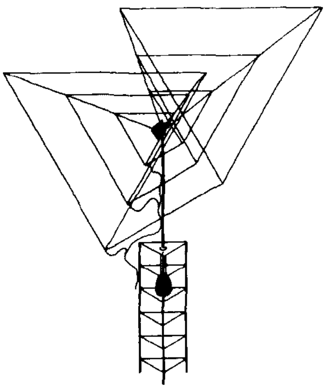

fig. 5. A three-band version. Note elements all properly spaced.

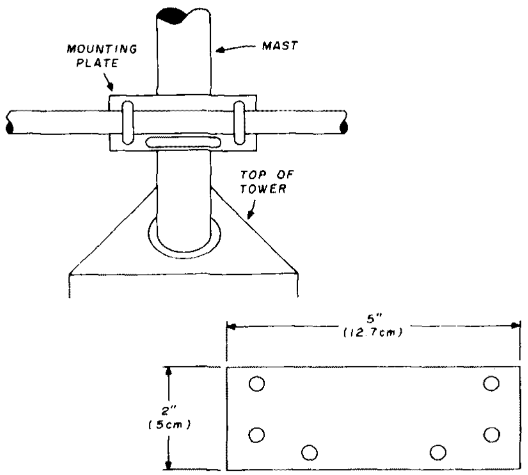

fig. 6. Mounting plate for bottom spreader. Any strong material may be used. Exact size and positions of U bolt holes to be determined by builder. The last step in the erection of the antenna is the proper positioning and securing of this plate on the mast.

1. Low torque applied to the rotator — there is no boom.

2. Full-size, two-element, wide-spaced quad.

3. Only four main spreaders instead of eight.

4. Wire elements mean the antenna is easy to feed.

5. Antenna completely above top of tower.

6. Lower cost because of fewer parts.

7. Lower weight because of very little metal.

8. Antenna symmetrical and well-balanced.

9. Antenna easy to fabricate and mount.

10. Easy addition of loops for other bands with simple addition of lower spreader for each new band.

11. Possibility to invert antenna to obtain gravity/balance advantage on tower.

I am very interested in hearing from those who have any comments, suggestions for improvement or questions regarding this antenna.

references

1. P.J. Kiesel, K7CW, "Ultimate Antenna Array," *ham radio*, August, 1978, page 30.
2. R.M. Myers, "Understanding High Frequency Antennas," *ham radio*, June, 1980, page 62 (third paragraph).

ham radio

ham radio TECHNIQUES

Bill Orr, W6SAI

It's the old story: RFI (radio frequency interference) is no problem if you don't have it, but it's hell if you do. This point was emphasized to me a few weeks ago when I became the proud owner of a new microwave oven. I was eager to buy it because of its advantages in quick-cooking — and the oven came highly recommended. No doubt about it: it was a well-made unit and we had a lot of fun doing some experimental cooking with it.

The only problem was that when the oven was running it obliterated the kitchen radio with a raspy sound like that of a chain-saw cutting through a hard oak knot, and it produced a broad, wiggly band across TV channels 2, 4, and 5. I could also hear the same raspy noises on the 160- and 80-meter ham bands.

Now how could a microwave oven operating around 2 GHz cause such RFI on radio and television? The racket sounded so much like an SCR, or light dimmer, that I concluded that it might be the oven's power supply rather than its magnetron that was causing the interference (see **fig. 1**). I removed one end of the cabinet to expose the control circuits and power supply — and my guess was right. A simple half-wave rectifier system was used.

Holding a small transistor radio near the supply confirmed the source of interference. As far as could be determined, there were no shunt capacitors across the high-voltage rectifier to suppress diode noise or switching transients. And, obviously, no rf filtering in the power leads.

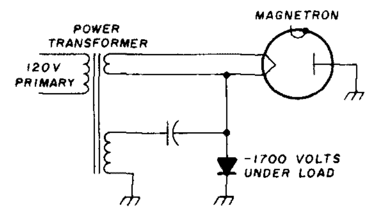

fig. 1. Representative high-voltage power supply for the magnetron in a microwave oven. Voltage under standby load is −2800 volts, dropping to −1700 volts under full load. The RFI filter is placed in primary circuit of the power transformer.

I decided to call the factory about the problem, as I didn't relish the idea of digging into the oven to install haphazard filtering. A phone call to the manufacturer in Iowa brought cold comfort. When I mentioned television interference from the oven, the serviceman immediately asked me if I lived near a Radio Amateur! (That *really* frosted me!) Finally, after admitting that the company knew nothing about the problem, the voice on the phone told me to call the local service depot in San Francisco.

I telephoned the local outfit and finally got through to a gentleman who would level with me (but only after I told him I was in the electronics business and knew what I was talking about).

He readily admitted the problem and said that the ovens manufactured for export outside the United States have an RFI filter in them, but those intended for use in the U.S. do not. (This clearly points up why this country requires FCC jurisdiction over RFI emissions from home entertainment equipment and appliances.)

The upshot was that the manufac-

turer would not *give* me a filter for their noisy product, but they would *sell* me one for $24 plus a dollar shipping. I bowed to this suggestion and mailed off a check. The filter soon arrived in the mail, and I must admit that it was a neat little package, made in Germany. It incorporated both a semiconductor device that protected the oven from line transients and a filter.

No information was included regarding mounting the filter, so I merely drilled a hole in the rear of the cabinet for the filter's single mounting bolt and sandpapered the paint away from the area where the filter would rest. The filter was equipped with residential-type snap-on terminals, and a quick trip to the hardware store turned up matching snap-on lugs. The power cable was snapped on one set of filter terminals and short leads were made up, going from the output terminals of the filter to the terminal board that originally held the power cable.

Once the cabinet had been reassembled, it was immediately apparent that the filter was doing its job. The TVI had disappeared, the racket was gone from the kitchen radio — and also from my receiver in the ham shack!

For those who have RFI from a microwave oven a good power line filter seems to be the answer. The filter I bought was Amana part number B-57178-1. It comes with a mounting bracket (which is useless); and there is no nut for the mounting bolt (but it's easily found in the junk box). To mount the filter, it is necessary to drill a 5/16-inch-diameter hole in the oven cabinet near the power cord. Doubtless the filter would work with other microwave ovens that have the same power rating as my Amana RR-5B.

The sixty-four dollar question is, knowing that the Radarange is a prolific source of RFI, Why doesn't Amana incorporate a line filter in all of their production instead of adding the filter only for the export models? Don't answer that — I know what the reply will be: Why spend a few cents per microwave oven for a filter when perhaps only one customer in a hundred complains of RFI? Consumer organizations seemingly cannot fight such a simplistic philosophy, and the manufacturers have a common ally in the *Electronic Industries Association*, which fights any suggestion of RFI legislation tooth and claw.

In any event, if you own an Amana microwave oven, you can get a filter for it. I'll be interested to hear from readers who have experienced this form of RFI, and I'd like to hear from owners of other brands too. Do other manufacturers incorporate RFI filtering in their products? Is Amana the only manufacturer that evades this problem? Or are they all in the same league? I'd like to know.

lightning protection

Summer is the time for thunderstorms. A cloud-to-ground discharge can have a potential of 300 million volts at hundreds of thousands of amperes. The damaging effect of a stroke results from the power developed by the passage of a large current through a resistance (a human body, for instance). A lightning arrester provides a controlled path to ground for the lightning energy, shorting it to ground before it can damage the equipment being protected.

A secondary effect of a lightning strike is the tremendous electrostatic field set up in the vicinity of the bolt — up to 5 kV/cm. When the strike reaches earth a great potential is set up between the strike point and "neutral" earth, and earth currents flow outward from the strike point to re-establish equilibrium. These currents can flow along the outside of a coaxial line located in the vicinity of a strike (see **fig. 2**). This potential can be induced into the inner conductor despite the presence of a lightning arrester in the line, or it can elevate the chassis of the radio equipment to thousands of volts above ground — even though the equipment is normally at ground potential.

One simple way to prevent the coaxial line from rising above ground potential is to pass it through a very simple waveguide-beyond-cutoff filter made of a ten-foot-long piece of electrical (EMT) tubing. The coaxial line is passed through the tubing, and line and tubing are then securely grounded at the station end of the

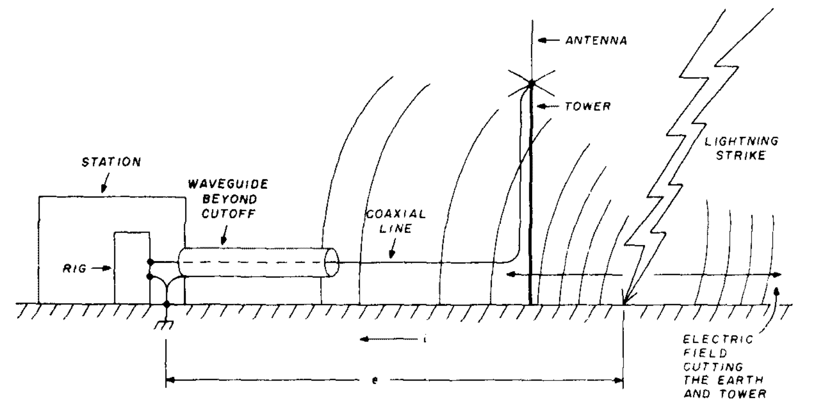

fig. 2. A lightning strike at or near an antenna tower can induce a potential drop in the earth with heavy ground currents flowing outward from strike point. Current is eventually dissipated in the earth. Ground current can be induced into the outer shield of coaxial lines with damaging effects to equipment, even though a lightning arrester is in the line. Ground waveguide and equipment at one point in the station with a heavy conductor to a good ground rod. A 10-foot-length of EMT tubing is used for the waveguide.

line (as shown in the illustration). The opposite end of the tubing is not grounded. The ground potential passing along the outer conductor of the line will be shunted back to earth at the grounded end of the filter, thus protecting the equipment, which is grounded to earth at the same ground point. When this approach is used in conjunction with a conventional lightning arrester, maximum protection is afforded the equipment in the hamshack during a thunderstorm.

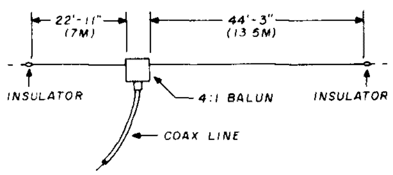

fig. 3. The off-center-fed antenna revisited. This version, used by JK1AYE, is designed for 7, 14, and 28 MHz operation, and it's fed via a coaxial line and 4-to-1 balun. SWR is quite low on all three bands. The antenna is not designed for 21-MHz operation.

simple antenna for 7/14/28 MHz

A recent issue of *CQ-ham radio* (Japan) described an interesting tri-band antenna used by JK1AYE. It is an updated version of the old off-center-fed antenna that used a 300-ohm ribbon line for the feed system (**fig. 3**). In this simple design, a 4-to-1 balun and coaxial line replace the ribbon line. JK1AYE adjusts the lengths of the flat top sections a bit at a time until he achieves lowest SWR in the middle of each band. He claims an SWR value of 1.6-to-1 at resonance on 14 MHz, less than 1.3-to-1 on 7 MHz, and less than 1.2-to-1 at resonance on 28 MHz. Because of the unbalanced antenna there is bound to be some minor radiation from the transmission line, and it is recommended that the line drop down to ground level directly below the antenna so that distortion of the antenna pattern is held to a minimum.

W1PLH revisited

In my March, 1982, column I described some interesting antenna designs used by Charlie, W1PLH. Here are the results of more of his antenna experiments.

The W1PLH-W1BCN compact 15-meter ground plane antenna. Shown in **fig. 4** is Charlie's answer to the problem of where to run radials for a ground plane antenna. Simply curl one radial into a circle. The W1PLH-W1BCN antenna is mounted with the feed point about thirteen feet above ground level. Results seem to be equal to those of a full-size radial system. The whip can be adjusted in length to zero-in the resonant frequency at the middle of the 15-meter band (about 21.2 MHz). Bandwidth is quite broad, showing SWR readings of less than 1.8-to-1 at the band edges and near unity at the middle of the band.

The W1PLH 75-80 meter dipole. In my March column I showed a drawing of the W1PLH 80-meter antenna. Charlie has modified this a bit and now gets very low SWR readings across the entire 80-meter band (**fig. 5**). If you have enough trees or supports to hold this antenna about twenty-five to thirty feet in the air, it should prove to be a good, all-round radiator for the complete band —

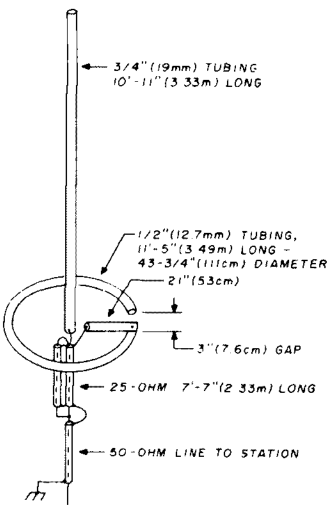

fig. 4. A version of the W1PLH/W1BCN compact 15-meter ground plane. A single radial is bent into a circle lying in the horizontal plane. A short length of aluminum tubing is used to make the connection between the circular radial and outer shield of 25-ohm, quarter-wave transformer section. The transformer is made of two sections of 50-ohm line connected in parallel. Be sure to waterproof all joints of the cables.

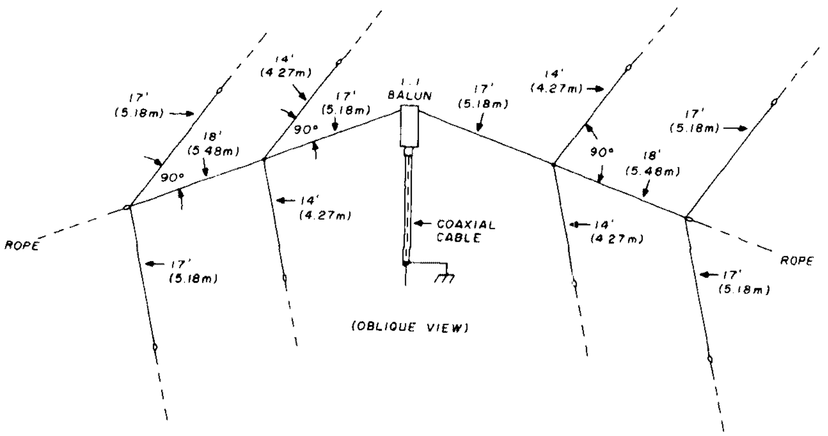

fig. 5. The W1PLH broadband 80-meter short dipole. The antenna is mostly in the horizontal plane with the fan wires sloping down a bit toward the ground. The antenna can be tuned by adjusting the length of the 17-foot-long sections. All portions of the antenna need not be parallel to the ground (a virtual impossibility if you have a lot of trees in the area).

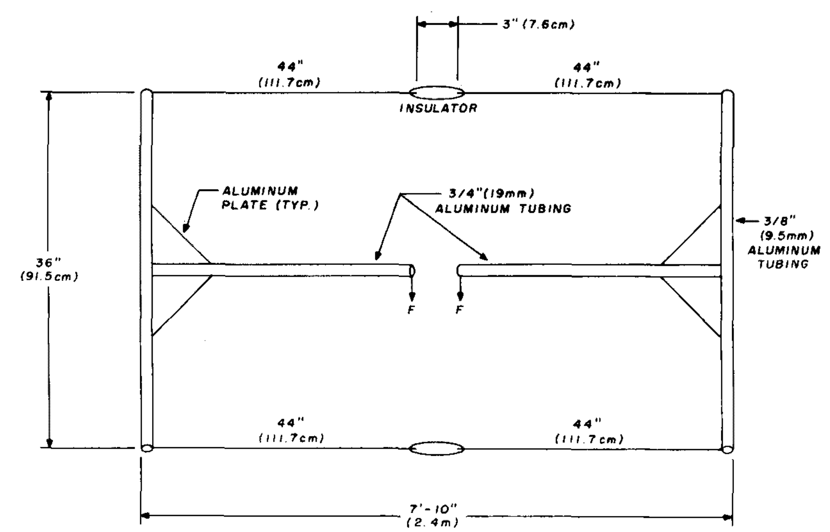

fig. 6. The W1PLH compact 10-meter dipole. It may be placed in either a horizontal or vertical plane. The feedpoint, F-F, exhibits a very low impedance and the antenna is matched to a 50-ohm line via a 1-to-1 balun and a linear transformer made of two sections of 50-ohm coaxial line 5 feet 6 inches (1.67 m) long connected in parallel. A 50-ohm transmission line is used. The end tubing is held to the center tubing by a small aluminum plate pop-riveted in place.

both phone and CW sections! SWR is about 2.4-to-1 at the band edges and near unity at 3.75 MHz. The array is tuned by adjusting the seventeen-foot end sections.

The W1PLH 10-meter compact dipole. Want a small, unobtrusive antenna for 10-meter operation? Charlie has constructed this small antenna that's only 7-1/2 feet long (**fig. 6**). It's a dipole folded back upon itself and fed via a quarter-wave matching transformer. The pattern is bidirectional and the bandwidth between the 2-to-1 SWR points is about 900 kHz. At the resonant frequency (28.5 MHz), the measured SWR is about 1.2-to-1 or less.

The main, central portion of the antenna is composed of two pieces of 3/4-inch-diameter aluminum tubing, each piece 44 inches long. The center junction is made up of a short plug of Lucite, Plexiglas or phenolic material. At the ends of this short dipole, 36-inch-long outriggers are attached by means of triangular aluminum plates. The outriggers are made of 3/8-inch-diameter aluminum tubing. The ends of these rods are flattened and drilled for small bolts, and the outer wires (insulated at the center) are attached to these points. The insulators in the wire are made of 3-inch-long sections of plastic rod.

Although drawn in the vertical plane for clarity, the assembly is supported in the horizontal plane with all sections parallel to the ground. And, as with any other antenna, the higher this little dipole is placed the better it will work.

a personal note

At long last, the twenty-second edition of the *Radio Handbook* has come on the market. It is now sold by all the leading electronic distributors and can also be obtained at the *Ham Radio Bookstore*. This 1200-page, hardbound handbook covers hf and VHF communications from A to Z, and from 160 meters to the new 920-MHz ham band. As the editor, I take pride in this new edition! I know you will enjoy it and find it useful!

ham radio

Questions and Answers

Entries must be by letter or postcard only. No telephone requests will be accepted. All entries will be acknowledged when received. Those judged to be most informative to the most Amateurs will be published. Questions must relate to Amateur Radio. In the case of two or more questions on the same subject, the one arriving the earliest will be used.

I have two questions that I've often wondered about and would appreciate your looking at.

I've often noticed that transmitter power is rated in terms of peak envelope power (PEP). How can I use this figure to estimate the approximate output power of the rig?

Also, I have an older transceiver that displays a mild hum on the received signals, just enough to cover very weak stations. How can this hum be eliminated, and what causes the power supply to jump somewhat when it is first turned on? — Christopher B. Hays, WB0LPV.

As for power output, the Amateur service is the only one in which power limitations are expressed in terms of final-stage input power. In all other services, the output power is used. With certain exceptions, the Amateur limit is 1000 watts to the plate circuit of the final amplifier; while FCC 97.67 doesn't say so, this means the product of the dc plate voltage and the current. This is known as the average power.

When we modulate the transmitter we get an envelope containing the modulation that has peaks and valleys — but there is no simple relationship between the peak and the average level of the human voice. So we "assume" that the PEP is twice the average power. Hence, the limit of 2 kw PEP, or 1 kW CW or average.

Now, the *output* power is a question of the efficiency of the transmitter's output stage. Assume 55 percent efficiency. If the transmitter is rated at 180 watts *input* CW, its output is 100 watts CW. If it is rated 360 watts PEP *input*, it will yield 200 watts PEP output — which is still 100 watts CW! Your primary interest is *output* power. Since PEP is a function of the individual voice, there is no standard of comparison other than average power output.

As for your "older" transceiver, I have to make some assumptions. My first assumption is that it is a tube-type. If the hum is 60 Hz, it can be heater-to-cathode leakage, remedied by tube replacement. If it is 120-Hz hum, it probably means your filter electrolytic capacitors need replacement — they have a finite life. Also, the cathode bypass capacitors in the audio stages of the receiver section should be checked.

That "jump" you refer to is usually a "grunt" from the power transformer that results from high inrush current. Assuming solid-state rectifiers, when the radio has been off, the filter capacitors look like a short-circuit until they charge. Also, some power transformers are designed so that they are operated at high flux density and with low primary-winding resistance, thus causing a "grunt" that depends on when in the 60-Hz supply cycle they are turned on.

I have a question about the efficiency improvement of a beam antenna. Would it be possible to have a gain in dBs if the beam could be rotated not only in the horizontal but also in the vertical plane, say in line with the radiation angle? Since the latter could be found only by experimenting for the best gain, rotation should also be a possibility. I wonder if any tests have been done in this respect. — Hans W. Schaedel, VE3BWE.

Thirty years ago, there was a ham in Chicago who used two rotators on his 10-meter beam, one for horizontal azimuth and the other for vertical radiation angle. I remember that when we could no longer hear other stations (this was at distances of 15 miles), he would still be very strong because he "tilted" his boom for maximum received signal. The only formal reference I could find was in regard to NBS studies of ionosphere opacity at 50 MHz, but there were no definitive conclusions that are applicable here.

The propagation experts claim that after one skip off the ionosphere the transmitted wave changes polarization, becoming more vertical or circular than it was at the transmitting antenna (which was horizontally polarized). This idea of adjusting vertical radiation lobe angle from ground is

intriguing, but I think you will agree it becomes somewhat *impractical* with large Yagis; the mechanical problems are difficult to solve.

I might suggest you try a combination: a vertical with a good radial system, a Yagi on a tower than can be raised and lowered, and a horizontal long wire close to ground. By switching among these antennas you might be surprised by the difference in received signals. And you may be surprised to find that the "reciprocity theorem" (that transmitting and receiving capability should be the same) doesn't always hold true! A combination of antennas with different vertical radiation angles can accommodate many point-to-point communications situations. And then there are the slopers and drooping inverted-Vs — if you have enough real estate, you can have a ball.

Why is it when I use my rig on SSB that the current meter shows only about half the tune-up (plate) current and the wattmeter shows only about half the (output) power? — Mike Bruce, KA4BCM.

The answer is found in the characteristics of human speech and the mechanical (ballistic) characteristics of meters. When you tune up on CW, you are injecting a fixed-level audio signal into the low-level audio circuits, or the balanced modulator is set so an actual carrier is transmitted, depending on the type of transceiver/transmitter.

Now, when you speak into the microphone, you no longer have a fixed-level signal. The ratio of peak-to-average in the human voice is about three to one or more; speech is not sinusoidal. When using meters (plate-current, power, VU, etc.), the ability of the meter to follow these instantaneous changes comes into play — the meter needle moves slowly at first, might overshoot, miss a short burst of energy entirely, and slowly settle back. The type of meter you should use to monitor your modulation level is called an oscilloscope — it is not affected by these ballastic problems to any significant degree. *Then you can set your mike control to* produce maximum peak output power without flat-topping or distorting. Incidentally, an interesting question arises: How do manufacturers arrive at the ALC maximum line on their meters? I'll wager it's done with a constant-amplitude audio signal at one frequency. So again, use a scope!

What can you tell me about the "gray line," and how can I use it for DX? — Donald G. Ramras, KD6GR.

This topic involves the subjects of short-wave radio propagation and astronomy. Simply, the "gray line" is the "twilight zone," that is, the portion of the earth that delineates daytime from nighttime. This line (really a band) usually occurs ± 30 minutes on either side of local sunrise and local sunset, so we have about two hours of gray line per day. It has been found that hf propagation along this line is extremely efficient. The popular reason given is that the D layer of the ionosphere is minimal or nonexistent then and the signals are not absorbed as they would be during the day.

Astronomy? The position of this path varies with the earth's inclination to the sun. The position of the path can be predicted with the use of a globe, and a piece of cardboard larger than the globe that has a hole cut in it, and a table of inclination angles from the North/South Poles for different dates. A commercial version of this globe specifically designed for the purpose of gray-line prediction is available in Europe.

Insofar as short- or long-path Great Circle propagation is concerned, a signal bounced off the ionosphere will take the path that has the least absorption. Again, this is related to D-layer absorption, affected by the sun striking the ionosphere. The *frequence optimum de travail* (optimum working frequency) for a given path (point-to-point) is determined by the maximum usable frequency, MUF, the highest frequency that can be used for transmission using reflection off the regular ionospheric layers. The MUF is affected by sunspot activity.

For those interested in pursuing this fascinating subject, the suggested bibliography is: *The Shortwave Propagation Handbook* by Jacobs and Cohen, from Cowan Publishing; *80-Meter DXing* by Devoldere, from Communications Technology, Inc., Greenville, NH; "The Gray Line Method of DXing," by Hoppe, Dalton, Capossela, *CQ*, September, 1975; and *The ARRL Antenna Book*, Chapter 1, from the American Radio Relay League.

I need a clear, concise definition of an rf ground. I have read that they can be important, especially with QRP operation. — Elliott Gee, KA4PQF.

An rf ground is one that makes a low-impedance connection with earth for frequencies in the radio spectrum. Now, for 60 Hz, it is not much of a problem to contact "earth." A fair sized conductor is connected to a single rod. To improve contact with earth, multiple rods (or radials) should be used, usually the more the better. When operating at rf, however, a problem arises — this single wire has inductance as well as resistance.

For instance, a ten-foot length of #10 AWG solid copper wire has a resistance of about 0.01 ohm and an inductance of 4.13 μH (assuming it's straight and that most of the current is flowing on its surface — skin effect). At 21 MHz our ground wire looks like 0.01 + j 552 ohms — not very effective! Also, consider that as rf travels along a wire there are standing-waves of voltage (and current) produced. The impedance at any point is the voltage divided by the current. Therefore, the solution is to use *several* ground wires of *different lengths*, avoiding lengths that are multiples of quarter-wavelengths in our bands. Then, if one length shows a high impedance at *the operating* frequency, it is probable that one or more of the other wires will be at low impedance to ground.

Starting from one common point in our shack (the "equipment ground" point), run these different lengths to our ground rods or radial system. Connect each piece of equipment with its own lead (try and keep them the same length to minimize potential differences) to this equipment ground. Use insulated wire so it doesn't rub against any metallic object and create noise. Make solid connections and inspect them periodically. Do not use water pipe or electrical wiring grounds. Use at least #10 AWG wire and keep the run as short as practical, usually out the window along the outside of the building to earth. If all else fails, consider using a counterpoise underneath your antenna. Good luck!

I would like information on the new WARC bands, phone and CW portions — Brian Grant, VE4ALR.

WARC-79 produced three new bands for Amateur use: 10, 18, and 24 MHz. The frequencies from 10.1 to 10.15 MHz, the first to be used, will be on a shared basis with fixed services, and the earliest date of use was to have been January 1, 1982. The other two bands, 18 and 24 MHz, will be exclusive — after the fixed service stations now using these frequencies are reassigned. That will probably be after mid-1989!

The 50 kHz of the 10-MHz band we have will be shared on a secondary basis; that is, they can cause interference to us, but we can't cause interference to them. There is some move toward CW-only use of the 30-meter band, but even this is not universally accepted.

Your British cousin went on the air on January 1, along with some other countries. Here in the States, the FCC is still contemplating the situation, listening to objections from current users of these frequencies and waiting for Senate ratification of the WARC-1979 treaty. It will probably be a while before U.S. hams use this band. Canada has use of this band now.

ham radio

operation upgrade: part 9

The ninth part in a continuing series designed to help you upgrade your ticket

The ninth article in this series on upgrading your license presents in reasonably simple terms what is in actuality quite a complete group of theories. The first article (September, 1981) discussed direct current circuits. This was followed by some alternating current theory, active devices Amateurs use, simple power supplies, and practical amplifier circuits. The last two articles discussed the fundamentals of CW transmitters and receivers.

This month we will investigate the radiation of radio frequency energy, or waves, from wires, some basic antennas, wave motion through space, transmission lines, and the SWR meter. You should understand that, without a properly operating antenna, even maximum power input to a transmitter may not produce satisfactory communications.

electromagnetic radiation

When an antenna wire is fed rf ac energy, electrons are forced to oscillate back and forth along the wire. This produces an alternating electromagnetic field around the wire, and an alternating electrostatic field from one end to the other end of the antenna. We will consider only the electromagnetic part, but remember that it could not exist without the electrostatic field being there also.

The fundamental center-fed dipole-type antenna is shown in **fig. 1**. It consists of a half-wavelength ($\lambda/2$) horizontal wire, fed in the middle by a two-wire transmission line (feeder, or feed line). The bottom of the feed line is coupled to a transmitter (if you want to transmit energy) or to a receiver (if you want to receive energy picked up by the antenna).

The antenna wire can be cut to the basic $\lambda/2$ length from a formula based on the velocity of radio wave travel in meters per second (the velocity is roughly 300,000,000 m/s). For a frequency of 7 MHz, or 7,000,000 cycles per second (Hz), the full wavelength can be determined by dividing the velocity by the frequency. So, a 7-MHz signal has a wavelength of

$$\lambda = \frac{300,000,000}{7,000,000} = 42.857 \text{ meters}$$

If 7-MHz ac has a wavelength of 42.857 meters, its

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north magnetic field being radiated from the antenna would travel 42.857 meters outward in the air before the next north magnetic field would be produced around the wire. During this period, the field around the wire would decrease to zero, become a south-polarity field, reach maximum, decrease to zero, and expand out to maximum north again. The magnetic fields build out and back because an alternating electron current is being driven back and forth in the wire by the transmitter. Although 42.857 meters is the full wavelength of a 7-MHz ac wave, the wire can be cut to a half-wavelength ($\lambda/2$) and still allow the electrons to oscillate back and forth in it with minimal opposition.

We might expect that a 7-MHz, $\lambda/2$ antenna would be 42.857/2, or 21.4 meters long. But that's too easy. A properly operating $\lambda/2$ antenna will be only about 95 percent of our computed length, because of "end effects." You can use one of the following formulas, which include the 5 percent end effect correction, when computing the correct length of a $\lambda/2$ antenna:

$$\text{In meters, } \lambda/2 = \frac{142.5}{f_{MHz}}$$

$$\text{In feet, } \lambda/2 = \frac{468}{f_{MHz}}$$

According to your own calculations, to what length should you cut a 7-MHz $\lambda/2$ antenna wire? How about 20.357 meters, or 66.857 feet? Do you agree?

An interesting point regarding an antenna is its impedance. If you were to measure the impedance of a $\lambda/2$ antenna end to end it would be something like 2500 ohms, depending on wire size, height, and so forth. If you cut a $\lambda/2$ antenna in the middle, this opening should exhibit an impedance of about 72 ohms to any feedline coupled to it, again depending on conductor size and height. We will say that a $\lambda/2$ antenna has a center impedance of about 72 ohms. If we connect a pair of wires of just the right diameter and spacing they can also be made to have a characteristic impedance of 72 ohms. If such a parallel-wire transmission line is fed 7-MHz rf ac, it will transfer all of its energy to the 72-ohm opening at the antenna center and all of this energy will be radiated into space by the antenna. Actually, a $\lambda/2$ antenna exhibits a 72-ohm impedance when at any quarter-wavelength ($\lambda/4$) multiple above the ground. If it's only an eighth-wavelength ($\lambda/8$) above ground, the center impedance drops to about 35 ohms. At 3/8-wavelength ($3\lambda/8$) above ground, it shows about 98 ohms. At $5\lambda/8$ above ground, it shows about 58 ohms, and so on. Above two wavelengths in height, the center impedance will be constant at 72 ohms.

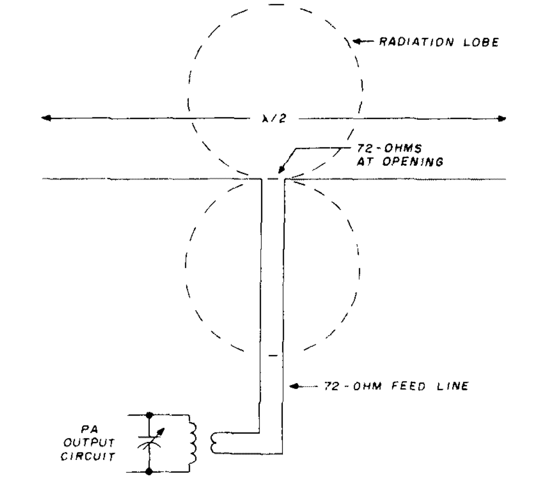


fig. 1. Basic dipole coupled to a power amplifier by a parallel wire transmission line.

Of course, if you change the frequency of the rf ac you are feeding to the transmission line from 7 to 7.1 MHz, the antenna will no longer be in resonance with the ac. The 66.86-foot antenna will now be a little too long (for 7.1 MHz it should be 65.9 feet). Electrons oscillating at 7.1 MHz will not have enough time to reach the end of the antenna before the ac cycle alternates and they must start back again. As a result maximum current never is produced in the antenna and some of the energy which the antenna is unable to accept is reflected back down the transmission line. The reflected energy develops high and low voltage points (loops and nodes) on the transmission line which can make the *line* act as an antenna and radiate rf waves. When the antenna is taking all of the energy and none is reflected back down the line, the voltage across the line at all points is equal and the line is said to be "flat."

When the antenna is not the proper length for the frequency of the ac being fed to it, then the impedance exhibited at the center will no longer be a resistive 72 ohms, and will no longer be a match for a 72-ohm line feeding it. An impedance mismatch always results in less than maximum power transfer, as discussed previously.

In the case of an antenna being too long for the ac frequency being fed to it, the antenna looks inductive (appears to have X_L) to the feeder. The inductive reactance can be cancelled by opening both wires of such a dipole (two $\lambda/4$s makes a $\lambda/2$) and adding the correct value of capacitance (X_C) to bring the antenna back into resonance. The antenna will now be resonant to the exciting ac and no standing waves (high and low voltage and current points) will be developed on the feed line.

An antenna that is too short for the ac frequency will appear capacitively reactive to the driving source (feed line). Both sides of the antenna can be opened and loading coils with the correct value of inductive reactance can be added to bring it to resonance and make it accept maximum power from the feeder. However, when an antenna is loaded to make it resonant, its center impedance may decrease somewhat.

basic vertical antennas

The basic horizontal antenna is the dipole discussed above. If such an antenna is rotated 90° so that the wire is oriented vertically (assuming the lower end does not touch the ground), it can be called a vertical $\lambda/2$ dipole. Maximum radiation of energy from any $\lambda/2$ antenna is always at right angles to the wire (E and W and skyward for a horizontal antenna laid out N and S). There is essentially no radiation off the ends. The radiation lobes of such an antenna are shown dashed in **fig. 1**. When the dipole is vertical it radiates nothing upward, but radiates equally well in all horizontal directions from the wire. It is said to have omnidirectional, or all-directional, lobes, whereas the horizontal dipole has bidirectional, or two-directional, lobes (disregarding the upward radiation component).

If a second $\lambda/2$ wire is attached to one side of the horizontal dipole we would have a full-wave antenna, fed at the center of one of its $\lambda/2$ sections. We could keep adding $\lambda/2$ sections to one side of the antenna, and the feedpoint could remain where it is. An unlimited number of such $\lambda/2$ sections could be added and it would still be resonant. Whereas a $\lambda/2$ antenna has maximum radiation lobes at right angles to the wire, a 1λ antenna has two lobes, each about 50° from the wire. A $3\lambda/2$ antenna has one lobe at right angles to the wire and two at about 40° from the wire. A 2λ antenna has four lobes, a 3λ has six lobes, and so forth. Every time a $\lambda/2$ is added a new lobe is formed. As the antenna is lengthened the lobes of greatest length (those which contain the most energy) fall closer and closer to the wire. A 4λ or longer "long-wire" antenna becomes most directional in line with the antenna wire, rather than at right angles to it as in a $\lambda/2$ dipole.

It is also possible to use just half of a vertical dipole and use a "ground" connection to make the earth operate as the unlimited number of $\lambda/2$ sections for the other part of a long-wire antenna. In such a case a $\lambda/4$ vertical antenna is developed, **fig. 2**. The earth connection, called a ground, may be a series of four to perhaps twenty $\lambda/4$ wire radials extending out from under the vertical section, as shown. An electrical ground rod might be used but only if it makes a very good electrical connection to an area of exceptional electrical conduction (salt marsh, for example).

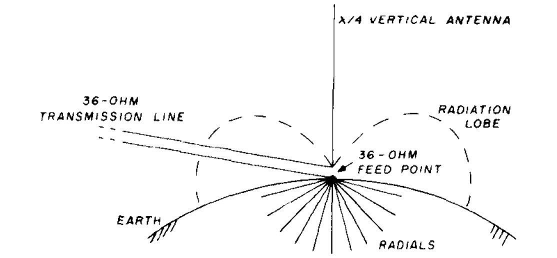


fig. 2. Basic $\lambda/4$ vertical antenna showing transmission line, ground radials, and radiation lobes (dashed).

If the ground system radials are buried under the ground they may be made less than a $\lambda/4$. If the ground is kept wet the radials may not need to be more than $\lambda/10$ long, nor number more than four or six.

The impedance of a vertical antenna, if the antenna wire is opened at the point where the ground radials converge, will be about half that of a horizontal dipole, or about 36 ohms. Feed lines are manufactured in 50-53 ohm and 73-75 ohm values. To match a 36-ohm feed point, two equal-length 75-ohm lines can be paralleled, or a 50-ohm line can be used and the mismatch tolerated (this produces an SWR of 50/36, or 1:1.39, discussed later).

A $\lambda/4$ vertical working against ground has an omnidirectional radiation pattern, but because of the reflection of the radiated wave from the nearby ground the horizontal part of the lobe will be somewhat shorter (shown dashed) than that of a vertical $\lambda/2$ well above ground. We can say the vertical $\lambda/2$ has more horizontal gain than the vertical $\lambda/4$ antenna. The better the ground under any antenna, particularly a $\lambda/4$, the better it will reflect waves from or to the antenna and the more gain the antenna will have.

The polarization of a radio wave is the direction taken by the electrostatic field of the antenna. Thus, a horizontal antenna transmits horizontally polarized waves, and a vertical antenna radiates vertically polarized waves.

solar and ionospheric effects

The earth is surrounded by a band of air, thickest near the earth's surface and thinning as altitude increases up to about 600 miles (1000 km). Ultraviolet energy radiated from the sun can cause ionization (breaking up of atoms and molecules of air in the higher altitudes into positive and negative particles). These ionized particles tend to form into reasonably well-defined bands above the earth's surface, and are referred to as the D, E, and F (F_1 and F_2) layers. Radio waves travel at higher velocity in the areas of lowest density. The top part of a wavefront starting

out at 45° above the horizon, for example, will begin to accelerate more than the part of the wave that started at 44°. This results in the top of the wavefront speeding up, causing the wavefront to bend back down toward the earth, **fig. 3**. Can you see that the same wavefront traveling at different angles from ground might return to earth at different places?

The part of a radio wave that travels directly over the surface of the earth will induce currents into buildings, trees, and the earth itself. It will lose energy and become weaker as it travels. Such a ground wave may produce readable signals for only a few miles if its frequency is in the high-frequency range. Low and medium frequency (VLF, LF, MF) radio waves may produce usable signals for hundreds to thousands of miles. Anyone in the area between the ground wave and the point where the closest reflected (or refracted) wave returns to earth is said to be in the skip zone. In the skip zone you will not be able to hear signals from the transmitter at all. As the day progresses, however, the ionospheric layers change density and the skip zone may close up — or it may lengthen. In general, the higher the frequency, up to about 30 MHz, the longer the paths that will be usable but the longer the skip zones may be. Above 30 MHz, radio waves may bend so little under normal conditions that they pierce the ionosphere instead of being refracted by it, as indicated by the nearly vertical ray shown in **fig. 3**.

It is quite common for one point on earth to be simultaneously receiving the same signal refracted from two different layers or from two different parts of the same layer. Since the path lengths of two such waves are different, the two signals may be in phase and augment each other at a receiver at one moment, or they may be out of phase and cancel each other the next. To the listener the signals are fading in strength. Because of changing solar activity, the ionospheric layers are continually varying in density. As a result, all signals out of strong ground-wave range will continually be fading to a greater or lesser extent. Even ground-wave signals with a path of over a couple of miles will fade to some extent, because of reflections from the ionosphere, from aircraft, or other variables. However, the true ground wave does not change in strength at all, day or night.

It is almost unbelievable how much difference there can be in the strength of two radio signals from the same station if only a couple of hundred hertz apart in frequency. An amplitude modulated (a-m) voice signal consists of a carrier frequency with sidebands out 3 kHz on both sides. If the carrier frequency fades out but the sidebands do not, the signal is still loud, but very badly distorted. As you listen to such signals, first the low frequency sidebands of the voice may fade out, and then the higher frequencies may fade. This is called selective fading and is one reason why single-sideband (SSB) emissions are so much more satisfactory than a-m. SSB signals have no carrier to fade and cause distortion.

During sunlight hours the layers are most dense. At night, the D layer thins and the two distinct F_1 and F_2 components thin out and rise to form a single F layer.

It is difficult to generalize on the daily variations of radio wave paths for the many different frequencies of our high-frequency bands. We might state that the low frequencies (1.8-2 MHz) are at their best at night for long-distance communications. The higher frequencies (28-30 MHz) tend to be better in the daytime for DX. Sometimes, when the solar activity is great, the layers are so dense that they attenuate radio signals of all frequencies outside of the ground wave range. In general, communications at 50 MHz and higher are made by line-of-sight (direct wave) only. If you can see the other station you can work it. However, VHF and UHF signals do bend down over hills, particularly if the hills present a sharp demarcation to the wavefront. As a result it is not unusual to be able to work such stations that are a little past line-of-sight. The higher your antenna the farther to both the visual and radio horizons. The approximate VHF and UHF radio horizon can be computed to be:

$$D = \sqrt{2h}$$

where D = distance in miles to the radio horizon

h = height of the antenna in feet

The formula allows for the fact that VHF and UHF radio waves traveling over reasonably flat terrain extend somewhat past the visual horizon.

It is possible to transmit radio waves upward and receive reflections back on earth a split second later. If the frequency of these ionosphere "sounding" emissions are checked, it will be found that at any particular time of day, above a certain frequency no return will be produced. From this the *maximum usable frequency* (MUF) can be determined. MUF charts are made up to indicate what frequencies might be best to use at specific times of day, for several days or weeks in advance. Such charts are particularly helpful when you're looking for DX contacts.

The D layer is present only when the sun is nearly directly overhead. If dense, it can absorb lower high-frequency-band radio waves. The E layer, about 75 miles up, is most effective at refracting signals during early morning and afternoon. Some solar flare-ups can develop a sporadic E layer, which can produce some interesting short-skip communications up to 1000 miles or more on the 28 and 50 MHz bands.

Most long distance high-frequency communications make use of refraction from the F layer(s).

Every eleven years the number of sun spots increases producing active DX radio communications. But at any time, if there is a spot on the sun with particularly high activity, its radio effect on earth may be felt again in twenty-seven days, which is the rotational period of the sun on its axis.

When there is a sudden ionospheric disturbance (SID) caused by solar flare-ups, many particles enter the ionosphere. All radio communications can be shut down for hours or days because of the absorption of the energy of radio waves by the highly ionized layers.

Solar particles may stream into the earth's magnetic field and produce visible ionization above the magnetic pole. This illumination is called the aurora, and, in the Northern Hemisphere, is visible roughly north of latitude 45. It is possible to bounce Amateur Radio signals off the auroral sheets and communicate for several thousand miles if both stations point their antennas at the ionized areas. CW is the best means of communications, because of the rapid flutter of such reflected signals.

The troposphere is the band of air from ground level up to about ten miles altitude. The air in the troposphere can form in warmer and cooler layers. Warm air is less dense than cool air, so when VHF or UHF radio waves are radiated into a strata of warm air between two cooler layers, they bend and travel along such a duct for hundreds of miles before the layer decays and they escape, possibly returning to earth. Ducting is most often experienced over large flat areas, such as oceans or deserts.

The variations normally present in air masses slightly above ground level are usable for what is termed *scatter* transmissions. High-power VHF or UHF radio waves are beamed at the horizon. Normal disturbances in the air 10 to 50 miles out can scatter the radio wavefronts. Some of the waves may be scattered in a downward direction toward earth and may be picked up as a usable signal several hundred miles away. Metallic wires and objects on top of hills can also produce a scatter effect bouncing signals down into a valley on the far side of a hill as seen from the transmitting station.

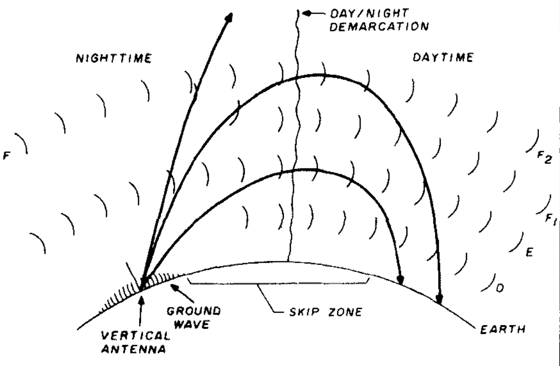


fig. 3. Effect of ionospheric layers on radio waves.

coupling the PA to an antenna

There are a variety of methods that can be used to carry radio frequency energy to an antenna from a transmitter. Remember that the far end of any antenna is its high impedance or high voltage point. Exactly $\lambda/4$ from the high impedance point will be the lowest impedance point. The high impedance point of a $\lambda/2$ antenna (or 1λ, 1.5λ, 2λ, etc.) can be directly attached to the high impedance end of the power amplifier (PA) tuned LC circuit, **fig. 4a**. In this way the impedances of antenna and PA tuned circuit are reasonably well matched and the antenna accepts rf power.

A $\lambda/4$ antenna has a high impedance at its far end, but $\lambda/4$ away there is a low impedance ($\pm$ 40 ohms) point. This end of the antenna wire can be looped and grounded, with the loop coupled to the PA tuned circuit as shown in **fig. 4b**. Since the loop adds inductance to the $\lambda/4$ wire a capacitor should be added to resonate the antenna. If the capacitor is variable it will allow resonating the antenna to any frequency in the band. Such an antenna may be $\lambda/4$, $3\lambda/4$, $5\lambda/4$, and so forth, in length. The third method, **fig. 4c**, is the pi-network described in previous articles. Bringing part of the antenna into the ham shack like this tends to induce rf ac into everything metallic in the shack. (You may be able to draw rf ac arcs off thumbtacks in the wall with a lead pencil!) Such energy is not being usefully radiated and can cause all kinds of difficulties in transmitters, receivers, and other electronic equipment. It is much better to install the antenna somewhere else and run a nonradiating feed line from transmitter (and receiver) to the antenna.

transmission lines

An important point to remember about transmission lines is that they should be matched with an impedance equal to their own characteristic impedance. The characteristic impedance that two parallel wires will have can be computed from the formula:

$$Z_o = 276 \log \frac{d}{r}$$

where Z_o = characteristic impedance in ohms

d = center-to-center distance of separation of conductors in inches (or cm)

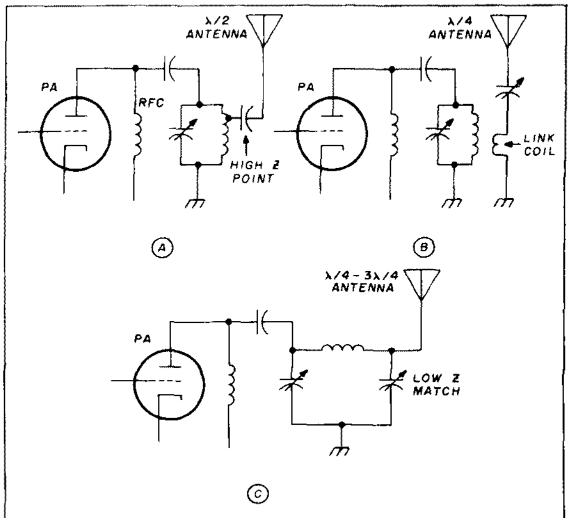


fig. 4. Shunt-fed VT power amplifier with (A) direct coupled λ/2 antenna; (B) link coupled λ/4 antenna; and (C) pi-network coupling system.

r = radius of the conductors, in inches (or cm)

If two wires of 0.04-inch radius are six inches apart, the Z_0 will be $276\ log(6/0.04)$, or $276\ log(150)$, or $276(2.176)$, or $600\ ohms$. Such a feed line would not match a λ/2 or λ/4 antenna having 72 or 36 ohm feedpoint impedances. However, if a λ/2 antenna has high impedances at the end and low at the middle, there must be two points equal in distance from the center where the impedance between the points is 600 ohms, **fig. 5**. This feeder-to-antenna coupling method is called a delta match system. If the λ/2 is exactly the correct length, the 600-ohm feeder energy will be accepted by the antenna and will be radiated. If the matching points are not properly selected, or if the antenna is not exactly λ/2 long, not all of the energy will be accepted and some will be reflected back down the transmission line, setting up points of high voltage (loops) and low voltage (nodes). The ratio of loop to node voltages is known as the standing wave ratio (SWR). If SWR is measured at high and low voltage points it may be called VSWR. (If measurements are made at current loops and nodes the SWR will be the same.) The SWR ratio tells us how well the antenna matches the feed line at the feedpoint. The greater the mismatch the higher the SWR. A perfect match would produce a 1-to-1 (1:1) SWR. A 1:2, or even a 1:3 SWR delivers a reasonably high percentage of the PA output power to the antenna. If you have SWR values above 1:3 you should probably improve your antenna system dimensions.

Although open-wire lines discussed above make excellent low-loss transmission lines, it is usually simpler to use coaxial ("coax") types of transmission line. A coaxial line has a center copper conductor surrounded by a solid but flexible plastic (polyethylene) insulating material. This in turn is covered by a metallic wire braid, which is then protected by a black rubbery outer insulating coating. The inner conductor and the braid (sometimes a solid metal tubing) form the two conductors of the transmission line. Whereas the open-wire lines are balanced types (neither wire is grounded), coaxial lines attach the braid conductor to ground, which makes them unbalanced.

A 72-ohm coaxial line coupled to the center opening of a λ/2 antenna which exhibits a 72-ohm impedance should theoretically transfer all of the rf ac energy from feeder to antenna — but it does not. The capacitance between outer braid to the two sides of the dipole antenna is not the same as the capacitance from the center conductor to the two antenna ends. This means the antenna and feeder are not balanced, so there will be some reflected power and standing waves developed both inside the coax and also along the outside braid. The standing waves on the outer surface of the braid cause the coaxial line to act as a vertical antenna and radiate energy. (The duty of any transmission line is to carry energy without radiating any of it.) A little vertically polarized radiated energy is not all that bad in transmitting, but for receiving, vertically polarized antennas usually tend to pick up more noise than horizontal antennas.

To properly couple an unbalanced coaxial line to the center of a balanced antenna, a balun should be used. This is a *bal*anced-to-*un*balanced rf transformer of some kind. It might be a 1:1 ratio toroidal (doughnut-shaped) transformer for the antenna-feeder difficulty above. If the coaxial line has a 50-

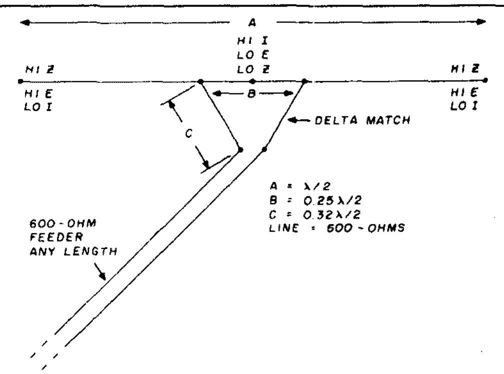


fig. 5. The delta match coupling system. Points of high and low E, I, and Z for a λ/2 antenna are indicated.

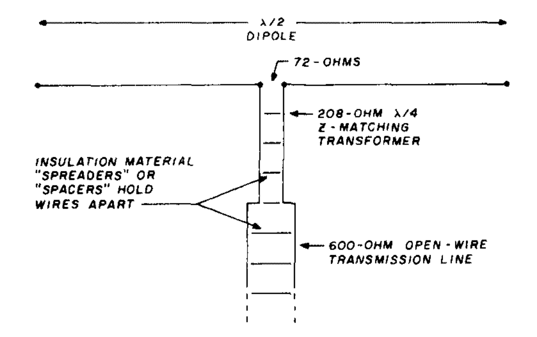


fig. 6. Using a λ/4 matching transformer to couple a 600-ohm feeder to a 72-ohm feed point.

ohm impedance and it is to match a 72-ohm dipole, the balun should have a 72:50, or a 1:1.44 impedance ratio. Its turns ratio should be the square root of the impedance ratio, or $\sqrt{1.44}$, or 1:1.2 in this case.

A quarter-wavelength-long transmission line can also act as an impedance changing transformer. For example, to match a 600-ohm balanced open-wire feeder to a 72-ohm dipole a λ/4 of transmission line between feeder and antenna can be used, **fig. 6**. The proper impedance for this impedance-matching transformer can be determined from:

$$Z_o = \sqrt{Z_1 Z_2}$$

where Z_o = λ/4 transformer impedance in ohms

Z_1 = antenna feed point impedance in ohms

Z_2 = feeder impedance in ohms

In the problem above, the impedance transformer should be constructed as a λ/4 open-wire line where $Z_o = \sqrt{72(600)}$, or *208 ohms*.

Resonant transmission lines (feeders cut to λ/4, λ/2, and so forth) can be used to match impedances also. Every λ/4 along a resonant feeder (or resonant antenna) the impedance changes from a high value to a low value. If a λ/4 wave open-wire line (any Z_o value) is coupled to the center of a dipole (a low Z point), at the other end of the λ/4 line a high impedance will appear. This end of such a balanced resonant line can be connected across the ends of a high impedance tuned LC circuit if it is grounded at the center. If the open-wire line is a λ/2 long, the low impedance at the antenna will be changed to a high impedance at the center of the line, but back to a low impedance at the transmitter end. A low impedance link coil of a few turns can be used to inductively couple from the PA LC circuit.

When a λ/2 horizontal dipole has one wire of an open-wire line attached to the end of the dipole, this is called a Zepp (from Zeppelin) antenna, **fig. 7**. To make the open end of the open-wire line match the high impedance at the end of a dipole, the feed line must be resonant. If the line is λ/4 long it will reverse the high Z at the end of the dipole to a low Z, which can be link coupled to a PA tuned LC circuit. If the feed line is λ/2 long it will repeat the high Z of the end of the dipole and will have to be coupled across the high Z of the PA tuned LC circuit. Since one of the feed lines of a Zepp antenna terminates in the air, the system is not well balanced. This can be corrected by adding a second horizontal λ/2 wire (shown dashed) to the unterminated feed line, making a double-Zepp (a 2-λ/2 in phase) antenna out of it.

For resonant open-wire lines the length in feet can be computed essentially as with antennas, but using $Length = 483/f_{MHz}$ for a λ/2. When coaxial lines are used, a velocity factor, caused by the slowing of wave travel through the solid plastic insulation between center conductor and braid, must be figured in. A polyethylene insulated coaxial cable will need to be only about 66 percent as long as an open-wire feeder. The length in feet for a resonant λ/2 coax cable can be computed by the formula, $Length = 319/f_{MHz}$. Here are some velocity factors used to convert electrical to physical lengths of different types of transmission line:

dielectric material used	velocity factor
air-insulated open-wire line	0.975
air-insulated coaxial cable	0.850
polyethylene parallel line (twin lead)	0.820
polyethylene coaxial cable	0.660

The efficiency of an antenna system is essentially

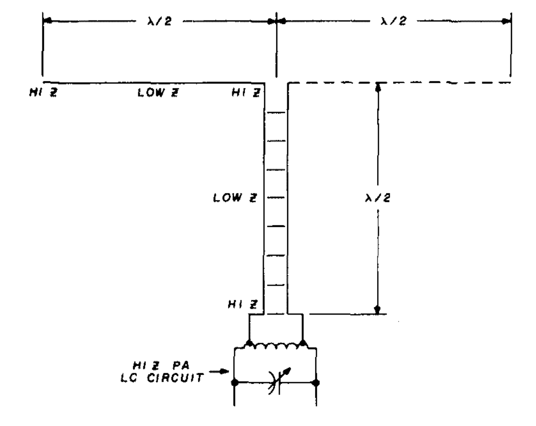


fig. 7. Half-wavelength Zepp antenna with λ/4 feeder. Adding dashed λ/2 balances antenna better.

that of the feeder system. There is usually little resistance in an antenna wire to lose power due to $P = I^2R$. Open-wire lines, unless many wavelengths long, may also have very little ohmic resistance and losses. Solid dielectric coaxial cables, however, do have losses. For example, at a certain frequency, a 100-foot-long piece of coax may have a loss of 3 dB. This is a loss of just half power. If 100-watts is fed into the coaxial cable, at the antenna end the power delivered and radiated (assuming a 1:1 SWR) will be only 50 watts. In this case the effective radiated power (ERP) is only 50 watts. Suppose an antenna system has a 2 dB loss in the coupling circuit, a 3 dB loss in the transmission line, and a 1 dB loss in the resistance of the antenna, the total loss would be 6 dB. If 3 dB represents a loss of one half power, then another 3 dB (total of 6 dB) represents a further one half loss, or a total loss to one quarter of the starting power. With 100 watts of rf ac from the PA tuned circuit, the ERP would be only 25 watts. It pays to have a well designed antenna system!

an SWR meter

We have mentioned that mismatching the feed line to the antenna feed point, as well as unbalanced feeder-antenna conditions, can produce a reflected signal back down the feeder that produces standing waves on the feed line. (Standing waves are desirable on resonant antennas, of course. The maximum voltage or current peaks developed on an antenna occurs when the feed line matches the antenna feed point.) But how can we determine the SWR on a transmission line? Is it possible to go along the feed line and measure the voltages present at different points? Perhaps, but this is quite difficult even with open wire lines. What we can do is to use a reflectometer, a meter that compares the energy moving up the feed line with that reflected back down the line. The ratio of the result of these two factors expressed in voltage or current will be the SWR.

If a wire is held a short distance from one feeder wire it will have voltage induced in it from the current flowing in the feeder. The reflectometer, or SWR meter, shown in **fig. 8**, is constructed to present a 50-ohm impedance to the rf ac from the 50-ohm coaxial cables coupled to it so that the meter itself will not reflect any standing waves back to the transmitter. Energy passing from the transmitter to the antenna through the middle conductor of the three wires induces a voltage into the top wire. This voltage affects the meter marked W/A (watts, mA). Any energy being reflected from the antenna feed point will induce a voltage into the lower meter wire and show up on the meter marked SWR. The two potentiometers ("pots") are ganged together. To obtain an SWR reading, first tune the transmitter (and antenna tuner,

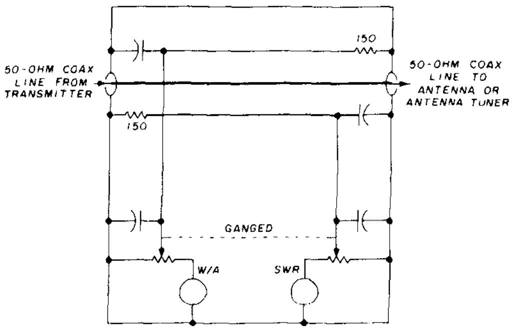


fig. 8. Reflectometer capable of giving SWR and power indications.

if any follows the SWR meter). Adjust the ganged pots so that the W/A meter reads exactly full scale. The reading of the SWR meter will be the standing-wave ratio on the transmission line. Now, retune any antenna tuner following the SWR meter to produce the lowest possible SWR.

This same SWR meter can be used for power indications. First, the antenna is tuned to minimum SWR. Then the ganged pots are set to the predetermined position for the band being used. What the W/A meter now reads is supposed to be the power being transmitted down the feed system. If the SWR is high the power indications may read considerably higher than is possible with the power input computed from PA power supply current and voltage ($P = EI$). If you read a power value much over 60 percent of the dc power supply input power to the PA you should regard the power readings with a jaundiced eye.

FCC test topics

The following Novice class FCC test topics are discussed in this article, but should be understood by Technician/General, Advanced, and Extra class license applicants also:

- frequency and wavelength
- ground wave
- sky wave "skip"
- parallel conductor feed lines
- coaxial cable feed lines
- quarter-wave vertical (dimensions)
- half-wave dipole (dimensions)
- possible causes of unacceptable SWR readings
- acceptable SWR readings
- ground system

The following Technician/General class FCC test topics are discussed in this article, but should be un-

derstood by Advanced and Extra class license applicants also:

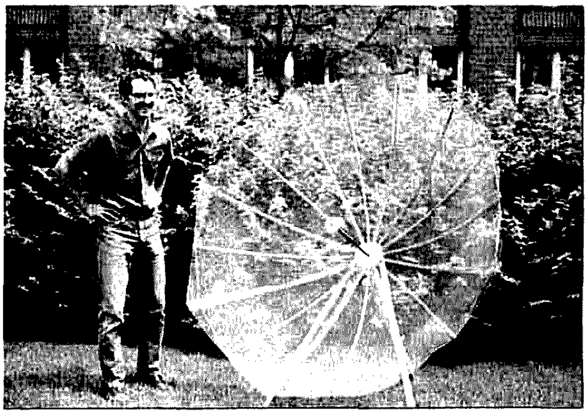
- vertical and horizontal polarization
- antenna orientation
- feed point impedance; half-wave dipoles, quarter-wave verticals
- line-of-sight communications
- ionospheric layers, D, E, F_1, F_2
- absorption of radio waves
- sunspot cycle
- regular daily variations
- sudden ionospheric disturbances
- ducting, tropospheric bending
- scatter transmissions
- maximum usable frequency
- balanced, unbalanced feed lines
- characteristic impedance of antennas
- antenna-feed line mismatch
- standing-wave ratio, significance of
- physical dimensions of antennas
- use of a reflectometer (VSWR meter)
- sidebands
- single sideband emission
- radiation patterns, directivity, major lobes
- attenuation in antennas

The following Advanced class FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

- electromagnetic radiation
- wave polarization
- radio-path horizon
- sporadic-E
- auroral propagation
- selective fading
- electrical length of feed lines
- efficiency of antenna
- effective radiated power, given system gains and losses
- velocity factor
- radiation resistance
- loading coil
- voltage and current nodes and loops

For additional information on these subjects you can refer to *Electronic Communication*, or to *Amateur Radio Theory and Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through Ham Radio's Bookstore, Greenville, New Hampshire 03048.

ham radio



a homebrew microwave antenna

Design and construction of a parabolic reflector with dipole feed

A major expense in a satellite ground receiving system is the high-gain antenna.[1] Most Amateur satellite trackers will want to build their own antenna to reduce this expense. Thus, we present a homebrew 68-inch (173-cm) parabolic antenna designed for receiving the 1691 MHz Geostationary Operational Environmental Satellite (GOES) weather facsimile (WEFAX) signal. The reflector of our antenna is identical in size and shape to a surplus reflector we obtained from a 12-GHz radar system. Using the same feed components and receiver with each reflector, we were able to test the gain of the homemade versus the commercial reflector. We found the homemade antenna's gain was within 1 dB of that of the commercial antenna. This difference is most likely due to variations of $\frac{1}{10}$ wavelength (approximately 2 cm) in the reflector's surface. We did not go to great lengths to perfect these surface irregularities, so most antennas built with this design should perform as well or better than our version. **Fig.** 1 gives dimensions of the antenna.

The absolute gain of the antenna has not been tested. However, by comparing our receiving sys-

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tem's overall performance (that is, signal to noise) with a GOES-WEFAX link calculation[2] it appears that the gain of our two antennas is within 2 dB of the theoretical gain. This indicates that for our parabolic dish at this frequency, our dipole feedpoint design[3] is good.

construction details

The reflector was designed to be simple and inexpensive without sacrificing performance. This was accomplished by using a single machined part for a base, 1/2-inch aluminum tube for ribs, and 4 × 4 hardware cloth for the reflector surface. The dipole feed (**fig. 2**), which is more difficult to construct, is made from 3/8-inch brass rod and 9/16-inch O.D. (0.065-inch wall thickness) brass tube. An alternative tubing that may be easier to obtain is 1/2-inch O.D. with 0.032-inch wall thickness. The advantage of this size feed line is that it is very easy to connect to a UG-58/U connector (type N).

The base of the antenna is machined from 3/4-inch aluminum stock as shown in **fig.** 3. After the base has been machined, building the reflector is straightforward. Insert two aluminum tubes in opposing holes and pull the ends together until they can be held securely with a 68-inch (173-cm) length of wire. A 16d nail inserted into the hole at the end of each rib will hold the wire in place. Once the tube is held in place, a check with a template (details in **fig. 4**) must be made to determine if the tube is curved in the shape of a parabola. Ours was not. Tension at the end of a tube will produce a true parabola only for shallower parabolas. For this deep parabola, judicious bends must be made in the tubes until a parabolic shape is obtained. After each pair of ribs is bent, set them aside until all are bent.

When all tubes are bent insert them into the base and string a 1/8-inch (3-mm) cable through the hole at the outer end of the ribs. Correct tension will be applied to the ribs if the wire measures 17.8 feet, or 5.4 meters, which is the 68-inch (173-cm) diameter circle. Fine adjustment of the cable length, and thus tension on the ribs, may be obtained by inserting a turnbuckle in the cable.

The screen is cut from 36-inch (91-cm) wide 4 × 4 hardware cloth as shown in **fig. 5**. The 36-inch (91-cm) width screen is the exact size needed so that the folded edges of wire will be on the outer rim, preventing many puncture wounds from sharp wires. Tie the screen to the ribs with short pieces of iron wire.

With the reflector finished, mount the feed by removing the UG-58/U and its collar, inserting the brass tube into the hole in the baseplate, and reattaching the UG-58/U (type N) connector and collar. It may be necessary to guide the center conduc-

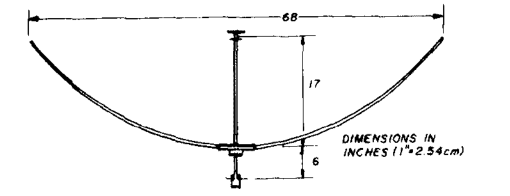

fig. 1. Overall dimensions of the antenna designed for receiving weather facsimile (WEFAX) signals on 1.691 GHz.

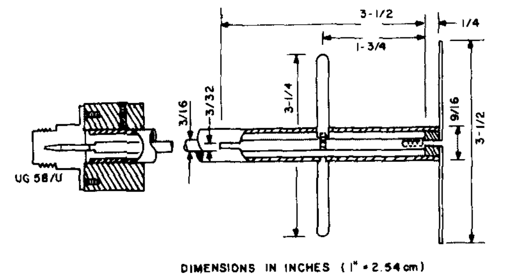

fig. 2. Details of the rear connector and dipole feed of the antenna.

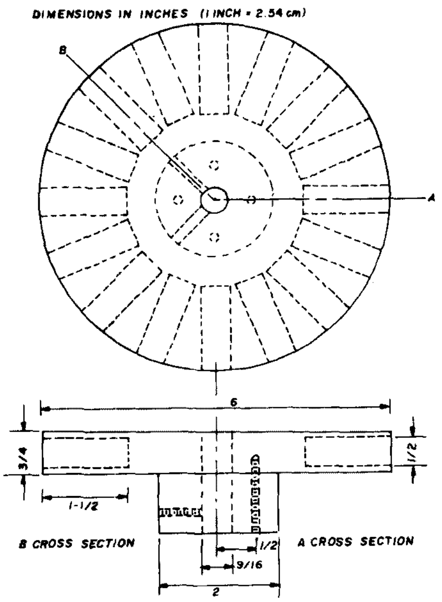

fig. 3. Details of the central hub of the reflector. Material is 1-inch aluminum stock.

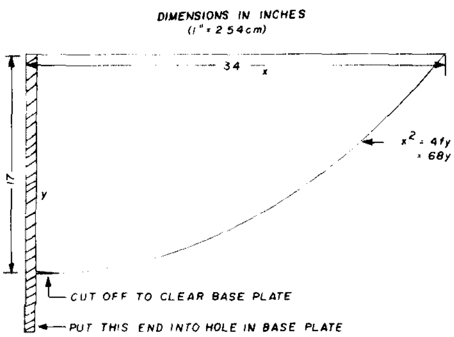

fig. 4. Details of the template used to form the reflector. Template is cut from card stock and taped to a 9/16-inch pipe to check dimensions and contour of the reflector.

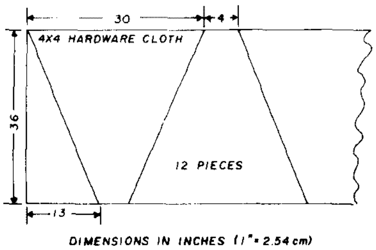

fig. 5. Pattern for cutting the hardware cloth used to form the reflector. Material is cut along the solid lines to form pie-shaped pieces.

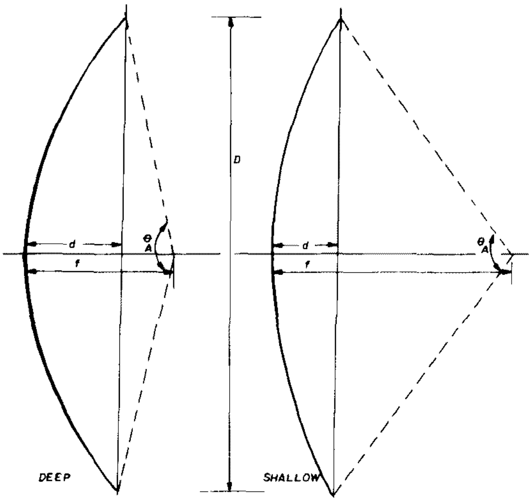

fig. 6. Comparison of deep and shallow reflectors. The aperture angle for an antenna of any given diameter depends on the focal-length-to-diameter ratio, f/D.

tor of the connector into the hole of the UG-58/U shell while slipping it on. Complete and partial kits are available from the authors.[4] Please send a self-addressed, stamped envelope for details.

After the receiver is hooked up, adjustments for polarization and focal point can be made.

designing your own antenna

The trick of designing antennas with parabolic reflectors is to match the beam width of the feed with the aperture angle of the antenna. There are several types of microwave feeds, each of which has a characteristic beamwidth. Beamwidths range from very broad for dipole feeds to quite narrow for horn feeds.

The aperture angle for an antenna of any given diameter depends on the ratio of the focal length to the diameter (**fig. 6**). For this reason, parabolic reflectors are described by diameter, D, and the focal-length-to-diameter ratio (f/D). Because the match of the feed with the antenna depends only on the f/D ratio, a particular feed can match a reflector of any diameter. The aperture angle, θ_A, in terms of f/D is

$$\theta_A = 2\tan^{-1}\left(\frac{1}{2a - \frac{1}{16a}}\right) \qquad \textbf{(1)}$$

where $a = f/D$

It is possible to determine the focal length of an existing reflector from the formula $f = D^2/16d$, where d is the depth of the dish. (See **fig. 6**.)

You may wish to construct a parabolic reflector of a different size and shape than the one presented here. One problem is determining the length of the tubing necessary for constructing a particular parabolic reflector. A formula giving the arc length is

$$s = \sqrt{4x^2 + y^2} + \frac{y^2}{2x}\ln\frac{2x + \sqrt{4x^2 + y^2}}{y} \qquad \textbf{(2)}$$

where $x = d$, $y = D/2$

For a parabola with a f/D ratio of 0.25, this reduces to

$$s = \sqrt{2y^2} + y\ln\frac{y + \sqrt{2y^2}}{y} \qquad \textbf{(3)}$$

where $y = D/2$

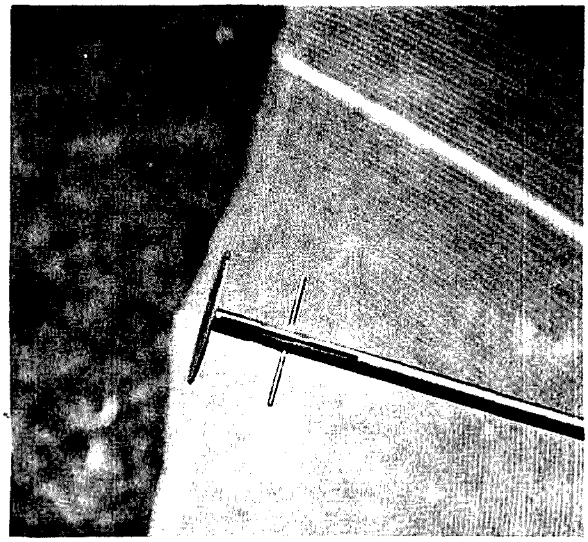

Photo of the feedpoint. The antenna may be redesigned for 1296 MHz or 2304 MHz by modifying the dimensions given for the 1691-MHz antenna. The 9/16-inch pipe is slotted on both sides of the dipole, although only one slot can be seen.

The choice of an antenna with a dipole feed has two general advantages: short focal length and rear feed arrangement. A short focal length makes it unnecessary to support a feed distant from the reflector. The rigid coax is both a support for the dipole and a low-loss waveguide that terminates at a convenient position at the rear of the antenna. The disadvantages are difficulty in constructing the dipole and the severity of bends in the reflector ribs.

Horn-feed antennas have nearly opposite advantages and disadvantages. Advantages are that there will be few or no adjusting bends necessary on the ribs with the shallower dish, and a horn feed is very easy to construct. The great disadvantage is in the difficulty in supporting and adjusting the feed for focus and polarization. Also, a length of hardline coax must be used to minimize loss if the preamp is not mounted out on the horn. Excellent directions are available[5] for construction of horn feeds.

references

1. D.H. Phillips, "Challenge for Microwave Antenna Designers," *ham radio*, August, 1980, pages 45-47.
2. N.M. Seese, "Ground Stations to Receive GOES WEFAX," NESS, NOAA, Dept. of Commerce, Washington, D.C. 20233.
3. S. Silver, *Microwave Antenna Theory and Design*, MIT Radiation Laboratory Series, vol. 12, McGraw-Hill, New York, 1949, page 254.
4. Northern Microwave, 306 9th St. S.E., Minneapolis, Minnesota 55414.
5. D.S. Evans and G.R. Jessop, *VHF/UHF Manual*, RGSB, London, 1967.

ham radio

HAM CALENDAR — September

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
			1 WEST COAST QUALIFYING RUN 10-35 WPM at 0400Z Sept 4 (9 PM PDT Sept 3) 1	**2**	**3**	**4** SOUTHERN COUNTIES ARA SPECIAL EVENTS STATION during the Miss America Pageant at the Atlantic City Convention Hall 4-12* ARUBA FIELD DAY 4-5
5	**6** WEST COAST BULLETIN 9 PM PDT (8 PM PST) 0400 UTC 3540 KCS A 1 22 WPM 6	**7** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**8** YL HOWDY DAYS sponsored by the YLRL from 1800Z Sept 8 to 1800Z Sept 10 8-10*	**9**	**10** AUGUSTA EMERGENCY AMATEUR RADIO UNIT'S NORTHEAST AREA HAMFEST Windsor Fairgrounds off Rte 17 10 miles east of Augusta ME 10-12	**11** 3RD ANNUAL GRANT COUNTY ARC HAMFEST McCarthy Hall St Paul's Church Marion IN 11 SUSSEX COUNTY ARC 4TH ANNUAL HAMFEST Sussex County Farm & Horse Show grounds Plains Rd, August, NJ 11 4TH ANNUAL BURNSVILLE FIRE MUSTER KNØS will operate from 1300-2200Z 11* PLATINUM COAST ARS 17TH ANNUAL HAMFEST Melbourne Auditorium Melbourne, FL 11-12 CANISTEO VALLEY RADIO AMATEURS special event station WB2SQX from 1400Z to 2100Z to commemorate 50th anniversary of Canisteo Living Sign 11* CRAY VALLEY SWL CONTEST 1800 GMT Sept 11 to 1800 GMT Sept 12 11-12* EUROPEAN PHONE CONTEST 11-12 ARRL VHF CONTEST 11-12
12 HALL OF SCIENCE AARC annual indoor outdoor Hamfest at Municipal Parking Lot 80-25 126th St Kew Gardens, Queens NYC 12 SUFFOLK COUNTY RADIO CLUB'S 5TH ANNUAL FLEA MARKET Odd Fellows Hall, Jayne Blvd Port Jefferson Station NY 12 4TH ANNUAL CENTRAL GEORGIA HAMFEST & ARRL STATE CONVENTION Warner Robins Recreation Center 800 Watson Blvd Warner Robins GA 11-12 THE FOUNDATION FOR AMATEUR RADIO'S 25TH GAITHERSBURG HAMFEST Montgomery County Fairgrounds Gaithersburg MD 12 SHAWNEE ARA 26TH HAMFEST John Logan College in Carterville IL 12 BUTLER COUNTY ARA ANNUAL HAMFEST Butler Farmshow Grounds Roe Airport Butler PA 12	**13** W1AW QUALIFYING RUN 10-35 WPM at 0200Z Sept 14 (10 PM EDT Sept 13) 13	**14** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**15**	**16**	**17**	**18** PEORIA ARC SUPERFEST 82 Exposition Gardens, W Northmoore Rd Peoria IL 18-19 GRAND RAPIDS ARA ANNUAL SWAP & SHOP Hudsonville Fairgrounds, Grand Rapids MI 18 WASHINGTON STATE QSO PARTY 18-19 SCANDINAVIAN C W CONTEST 18-19 NEW MEXICO QSO PARTY 18-19
19 45TH ANNUAL CINCINNATI HAMFEST Stricker's Grove, state route 128 Venice, OH 19 AUGUSTA ARC ANNUAL HAMFEST Julian Smith Casino Augusta GA 19 L'ANSE CREUSE ARC 10TH ANNUAL SWAP & SHOP L'Anse Creuse H S Mt Clemens MI 19 NORTH AMERICAN SPRINT 19	**20** WEST COAST BULLETIN 9 PM PDT (8 PM PST) 0400 UTC 3540 KCS A 1 22 WPM 20	**21** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**22** W1AW QUALIFYING RUN 22	**23**	**24**	**25** RADIO EXPO By Chicago FM Club, Lake County Fairgrounds Evanston IL 25-26 BEAUMONT TX ARC will operate W5RIN from 1700Z 2300Z Sept 25 and 26 during "Glady's City Boom Days" 25-26* 36TH ANNUAL WALLA WALLA HAMFEST Milton Freewater, Oregon 25-26 GREATER LOUISVILLE HAMFEST Kentucky Fair & Exposition Center Louisville KY 25-26 WICHITA ARA FIRST ANNUAL HAMFEST National Guard Armory Wichita Falls TX 25-26 7TH ANNUAL ELMIRA HAMFEST Chemung County Fairgrounds, Horseheads NY 25 SCANDINAVIAN PHONE CONTEST 25-26 MASSACHUSETTS QSO PARTY 25-26 MAINE QSO PARTY 25-26 DELTA QSO PARTY 25-26
26 ARRL HAMFAIR 82 sponsored by Long Island Mobile ARC at the Islip Raceway Islip Ave Islip NY 26 27TH ANNUAL YORK COUNTY HAMFEST York Fairgrounds, York PA 26 9TH ANNUAL LANIERLAND ARC HAMFEST Holiday Hall, Holiday Inn Gainesville, GA 26 CLEVELAND HAMFEST ASSOCIATION'S 8TH ANNUAL HAMFEST Cuyahoga County Fairgrounds, Berea OH 26 ADRIAN ARC 10TH ANNUAL HAMFEST Lenawee County Fairground Adrian, MI 26 6TH ANNUAL CONNECTICUT VALLEY FM ASSOCIATION'S HAMFEST King Ridge Ski Area New London NH 26	**27**	**28** AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)	**29**	**30**	**31**	

W1AW Schedule

April 25-October 24, 1982 — MTWThFSSn = Days of Week — Dy = Daily

W1AW code practice and bulletin transmissions are sent on the following schedule

EDT	Slow Code Practice	MWF 9 A M, 7 P M; TThSSn 4 P M, 10 P M
	Fast Code Practice	MWF 4 P M, 10 P M; TTh 9 A M; TThSSn 7 P M
	CW Bulletins	Dy 5 P M, 8 P M, 11 P M; MTWThF 10 A M
	RTTY Bulletins	Dy 6 P M, 9 P M, 12 P M; MTWThF 11 A M
	Voice Bulletins	Dy 9 30 P M, 12 30 A M
CDT	Slow Code Practice	MWF 8 A M, 6 P M; TThSSn 3 P M, 9 P M
	Fast Code Practice	MWF 3 P M, 9 P M; TTh 8 A M; TThSSn 6 P M
	CW Bulletins	Dy 4 P M, 7 P M, 10 P M; MTWThF 9 A M
	RTTY Bulletins	Dy 5 P M, 8 P M, 11 P M; MTWThF 10 A M
	Voice Bulletins	Dy 8 30 P M, 11 30 P M
PDT	Slow Code Practice	MWF 6 A M, 4 P M; TThSSn 1 P M, 7 P M
	Fast Code Practice	MWF 1 P M, 7 P M; TTh 6 A M; TThSSn 4 P M
	CW Bulletins	Dy 2 P M, 5 P M, 8 P M; MTWThF 7 A M
	RTTY Bulletins	Dy 3 P M, 6 P M, 9 P M; MTWThF 8 A M
	Voice Bulletins	Dy 6 30 P M, 9 30 P M

*SEE COMING EVENTS

FOR SALE: Icom IC-30A, 10W, 450 MHz radio. Best offer. WA6SBM, 335 S. Argyle #122, Fresno, CA 93727. (209) 255-4268.

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box R802, Council Bluffs, Iowa 51502.

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WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

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FOR SALE: Drake DC-4 power supply. Exc. cond. $85 plus PP and ins. John Austin, 207-03 Hillside Ave., Bellaire, NY 11427.

2 METER REPEATER: $250.00, 20 watt solid state commercial radio on your frequencies with COR and time-out timer. Make your own from my 30 watt solid state Motorola Motram, $150.00. Call Rick KC5EJ (915) 598-2796 or leave message at (800) 351-0001.

SELL: SB303 $230, SB401 $240, SB200 w/10m $230, made DXCC 290/260. K2LM, L. Reeves, RD3, Glens Falls, NY 12801. (518) 792-5533.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

COLLECTORS: HRO-5RA1, w/speaker, w/orig. manual. Best offer. K2LM, L. Reeves, RD3, Glens Falls, NY 12801. (518) 792-5533.

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HAM-AD-FEST™ — Next 6 issues, $2.00. WA4OSR, Box 973, Mobile, AL 36601.

BUGBOOK III: (Microcomputer interfacing) original edition for collector. Personalized autograph by author Adve Larsen, WB4HYJ $9.95 pp. Dave Larsen, 844 Hutcheson Drive, Blacksburg, VA 24060.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

(ROHN TOWERS) — Wholesale direct to users — all products available — write or call for price list — also we are wholesale distributors for Antenna Specialists and Regency FM radios. Hill Radio, PO Box 1405 — 2503 GE Rd., Bloomington, IL 61701 (309) 663-2141.

SAFETY BELTS. $35.00 and up. Free information. Avatar Co., (W9JVF) 1147 - (H) N. Emerson, Indianapolis, IN 46219.

WANTED: Old bugs for my telegraph and radiotelegraph key collection. I am trying to find each make and model of bug manufactured before 1950. Vibroplex, Martin, McElroy, Johnson, Logan, Bunnell, Signal Corps. A-Z Melehan, etc. Also need junkers for spare parts. K5RW, Neal McEwen, 1128 Midway, Richardson, TX 75081 (214) 235-8636.

CONTESTERS: Package of programs designed for the ARRL DX, CQWW, CQWPX and IARU Radio Sport Contests produces scored, duped log, dupe sheet, QSLs and many valuable operator statistics. TRS-80 Model 1, 48k, 1 or more discs, MX-80 printer required. $69.95 plus tax non-refundable. Sample printout with SASE. P. Chamalian, W1RM, P.O. Box 1188, Burlington, CT 06013.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Willams, PO #7057, Norfolk, VA 23509.

VERY in-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

Coming Events

ACTIVITIES

"Places to go..."

GEORGIA: The Augusta Amateur Radio Club's annual Hamfest, September 19, Julian Smith Casino. Admission $3.00 includes one prize ticket. Extra tickets $1.00 each. 6/$5.00. Tailgating $2.00. Barbecue and bingo for the family. Hospitality Room September 18, 4-11 PM, Ramada Inn West, Room 108-110. *Prizes: KDK-2030 2m FM,* Icom 2AT, and a surprise third prize. Talk in on 147.72/12. For information: John Schumacher, N4DOU, PO Box 3072, Augusta, GA 30904. (404) 860-4460. 6-9 PM EDT.

GEORGIA: The 9th annual Lanierland ARC Hamfest, September 26, 9 AM, Holiday Hall, Holiday Inn, Gainesville. Free tables/inside display for dealers and distributors. Large flea market, boat anchor auction. Prizes and activities. Free admission. Prize tickets $1.00 each; 6/$5.00. Talk in on 146.07-.67. For information: Phil Loveless, KC4UC, 3574 Thompson Bend, Gainesville, GA 30506. (404) 532-9160.

ILLINOIS: RA-COM '82 sponsored by the Mt. Prospect Amateur Radio Club and Cook County ALERT, October 3, Prospect High School, 801 W. Kensington, Mt. Prospect. Doors open 8 AM. Advance tickets $1.50; $2.00 door. Electronic flea market area, commercial exhibits, seminars, door prizes and more. Talk in on 146.52. For information and booth reservations: RA-COM, PO Box 89, Mt. Prospect, IL 60056. Please SASE.

ILLINOIS: The Peoria Area Amateur Radio Club's Superfest '82, September 18 and 19, Exposition Gardens, W. Northmoore Road, Peoria. Gate opens 6 AM, commercial building 9 AM. Admission: $3.00 advance; $4.00 door. Forums, displays, flea market. Sunday bus to Northwoods Mall. Full camping facilities. Saturday night get-together at the Heritage House Smorgasboard, 8209 N. Mt. Hawley Rd., Peoria. Free movies Saturday night at Hamfest site. Talk in on 146.16/76, W9UVI. For information and reservations: SASE to Superfest '82, 5808 N. Andover Ct., Peoria, IL 61615.

ILLINOIS: The Sangamon Valley Radio Club's seventh annual Hamfest, Sunday, September 26, Sangamon County Fairgrounds, New Berlin. Indoor/covered outdoor flea market. Exhibits, kids' activities, refreshments. Overnight camping available. Many prizes. Tickets $2.00 advance; $2.50 gate. For information: Ken Kiningham, K9IDQ, 2428 South State, Springfield, IL 62704.

SOUTHERN ILLINOIS Shawnee Amateur Radio Association's 26th Hamfest will be September 12 at John A. Logan College in Carterville, Illinois. Offerings include air-conditioned flea market, prizes, forums, computers, refreshments, contests. For details QSL Bill May, KB9QY, 800 Hilldale, Herrin, IL 62948 or 618-942-2511 days.

MARYLAND: The Foundation for Amateur Radio announces its 25th (silver anniversary) Gaithersburg Hamfest, Sunday, September 12, Montgomery County Fairgrounds, Gaithersburg. Saturday program includes a technical session, FCC forum and ARRL forum. Admission $4.00 each day, combination ticket $7.50. Proceeds provide scholarships to worthy students and subsidize Auto-Call, the Foundation's official journal. For information: Stuart Meyer, W2GHK, 2417 Newton Street, Vienna, VA 22180. Home: (703) 281-3806. Office: (703) 525-6286.

MARYLAND: The Columbia Amateur Radio Association's 6th annual Hamfest, Sunday, October 10, 8 AM to 3:30 PM, Howard County Fairgrounds (15 miles west of Baltimore). Admission $3.00, tables $6.00, tailgating

$3.00, indoor tailgating $5.00. Prizes, refreshments. Talk in on 147.735/135; 146.52/52. For table reservations or information: Sue Crawford, 6880 Mink Hollow Road, Highland, MD 20777. Phone 286-3805.

MASSACHUSETTS: ELECTRONICA — Boston's first public electronics show, Columbus Day weekend, Friday, October 8 through Monday, October 11, Hynes Auditorium. Personal electronics and home entertainment products, computers, games, ham radio, TVRO, CB, cameras, projection TV, security systems, video and stereo systems. Come see and buy the latest in electrotechnology.

MICHIGAN: The Adrian Amateur Radio Club's tenth annual Hamfest, Sunday, September 26, Lenawee County Fairground, Adrian. For tickets, tables, info: Adrian ARC, PO Box 26, Adrian, MI 49221.

MICHIGAN: The L'Anse Creuse Amateur Radio Club's 10th annual Swap and Shop, Sunday, September 19, 9 AM to 3 PM, L'Anse Creuse High School, Mt. Clemens. Admission: $1.00 advance; $2.00 door. Prizes include $250.00 first prize, $100.00 second and $50.00 third. Talk in on 147.69/.09 and 146.52. For information SASE to Maurice Schietecatte, N8CEO, 15835 Touraine Ct., Mt. Clemens, MI 48044.

NEW HAMPSHIRE: The 6th annual Connecticut Valley FM Association's Hamfest/Flea Market, Sunday, September 26, 9 AM to 5 PM, King Ridge Ski Area, New London. Adults $2.00. Children under 16 free. Flea market setup $5.00. Food concession by King Ridge. For information: KA1BWE.

NEW YORK: RAGS, The Radio Amateur of Greater Syracuse, annual Hamfest, Saturday, October 2, 9 AM to 6 PM, Art and Home Center, New York State Fairgrounds, Syracuse. Door prizes, tech talks, DXpeditions programs, contests, entertainment. Large indoor flea market. Admission: $3.00. Flea market space $6.00. Outdoor flea market space available also. Talk in on 90/30 and 31/91.

NEW YORK - LONG ISLAND: Suffolk County Radio Club's 5th annual Flea Market, Sunday, September 12, Odd Fellows Hall, Jayne Blvd., Port Jefferson Station. Rain date September 19. Door prizes, raffles, refreshments. Buyers $1.50 each, YLs, XYLs and harmonics, no charge. Sellers $3.50 each includes car and driver. Talk in on 145.21/144.61 repeater. For information: Floyd, WA2SDI, (516) 234-9376 after 6 PM evenings.

NEW YORK: The Yonkers Electronics Fair and Giant Flea Market, Sunday, October 3, 9 AM to 5 PM, rain or shine, Yonkers Municipal Parking Garage, Corner of Nepperhan Avenue and New Main Street. All-day demonstrations — computers, satellite TV, lasers, Hi-Fi/audio. Hourly prizes, giant auction, 50-50 drawings, instant bingo, free coffee all day. Admission: $2.00. Children under 12 free. Sellers: $6.00 per parking space, bring own table. For information: Yonkers ARC, 53 Hayward Street, Yonkers, NY 10704.

NORTH CAROLINA: The Western North Carolina Amateur Radio Society's seventh annual Autumnfest, October 9, Asheville Civic Center. Admission $3.00 advance; $4.00 door. Flea market tables $5.00 at door. Camping facilities available. Talk in on 31/91, 16/76 and 52. For information: WCARS, PO Box 1488, Asheville, NC 28802.

OHIO: The Findlay Radio Club Hamfest is celebrating its 40th anniversary on September 12, 1982, Hancock Recreational Center Arena, N. Main St., I-75, exit 161. Open 6:30 AM to 5:00 PM. Largest Hamfest in Northwest Ohio, second in state. Tickets $2.00 advance, $3.00 at entrance. Exhibit tables are $5.00 per table. Flea market trunk sales $2.00 per space. Open Saturday for setups and evening entertainment. Talk in 147.75/15. Check in 146.52/52. For reservations and tickets SASE to Findlay Radio Club Hamfest, PO Box 587, Findlay, Ohio 45840.

OHIO: The original forty-fifth annual Cincinnati Hamfest, Sunday, September 19, Stricker's Grove, State route 128, Venice (Ross). Exhibits, prizes, refreshments, flea market, talks, entertainment and a thrilling air show by the Hawks. For information request your copy of the Club magazine, "The Mike and Key" Hamfest Edition. W8ALW, WA8STX, K8CKI.

OHIO: The Cleveland Hamfest Association's 8th annual Hamfest, Sunday, September 26, Cuyahoga County Fairgrounds, Berea, 0800 to 1700 hours. Advance tickets $2.50 prior to August 31; $3.00 at door. Exhibits, forums, ladies' programs, outdoor flea market. Three main prizes and mobile check-in prize. Talk in on 146.52 with W8QV. For information: Cleveland Hamfest Association, PO Box 27211, Cleveland, OH 44127.

OREGON: The 36th annual Walla Walla Hamfest, Saturday and Sunday, September 25 and 26, Milton-Freewater, Oregon, Community Building. Free registration. Saturday opens 9 AM. Sunday 8:30 AM. Swap and shop, contests, prizes. Ladies bingo Camping at Fort Walla Walla

Park. Talk in on 52-52, 19-79, 04-64, 28-88, 16-76 and 3960 KC. For information: Walla Walla Valley ARC, PO Box 321, Walla Walla, WA 99362.

PENNSYLVANIA: The 27th annual York County Hamfest, Sunday, September 26, York Fairgrounds, York, 8 AM to 4 PM, rain or shine. Registration $3.00. XYLs and children free. Tailgating $3.00 per space plus registration. Inside tables $5.00. Hourly door prize drawings from 10 AM to 3 PM. Talk in on 146.37/.97 and 52/52. For information: Leroy Frey, K3POR, 170 S. Albemarle St., York, PA 17403.

PENNSYLVANIA: The Pack Rats Sixth annual Mid-Atlantic VHF Conference, Saturday, October 2, Warrington Motor Lodge, Rt 611, Warrington. Advance registration $3.00; $4.00 door, includes admission to Hamarama, Sunday, October 3, Buck County Drive-In Theater, Warrington. Flea market admission $2.00. Tailgating $4.00 per space. Own tables. Gates open 7:30 AM. Talk in via W3CCX on 146.52. For information: Hamarama '82, PO Box 311, Southampton, PA 18966 or Lee A. Cohen, K3MXM (215) 635-4942.

SOUTH CAROLINA: The 31st annual Rock Hill Hamfest, October 3. For information contact: YCARS, Box 4141 CRS, Rock Hill, SC 39730.

TEXAS: The Wichita Amateur Radio Society's first annual Hamfest, September 25 and 26, National Guard Armory, Wichita Falls. Dealer displays, computer demos, large flea market, ladies activities. Pre-registration $4.00, ends September 22. Pre-registration prize. Registration at door $5.00. Grand prize, ladies prizes and other prize drawings. Local talk in on 146.34/93 and 147.75/15. Reservations for tickets, flea market tables to: WARS Hamfest, PO Box 4363, Wichita Falls, TX 76308.

VIRGINIA: The ARRL Virginia State Convention and Tidewater Computer Show · Hamfest · Electronic Flea Market, Saturday and Sunday, October 9 and 10, Virginia Beach Pavilion, 9 AM to 5 PM both days. Admission $3.50 for both days. Computers, satellite equipment, XYL programs and free bingo. Free transportation to beach or for shopping. Cocktail party Saturday night. Advance ticket drawing for hand held transceiver plus many other prizes. Flea market tables $5 one day; $8 both days. For information and tickets: Jim Harrison, N4NV, 1234 Little Bay Ave., Norfolk, VA 23503. (804) 587-1695.

WISCONSIN: The Kettle Moraine Radio Amateur Club's annual Ham, Computer, Video Fest, Sunday, October 10, Waukesha County Expo Center, Waukesha, 8 AM. All indoors. Prizes, food, "happy hour". Tickets $2 advance; $3 door. Reserved tables $3 each 4'. Reservations until October 1. Talk in on 146.52. Send checks to KMRA Club, PO Box 411, Waukesha, WI 53187.

OPERATING EVENTS

"Things to do..."

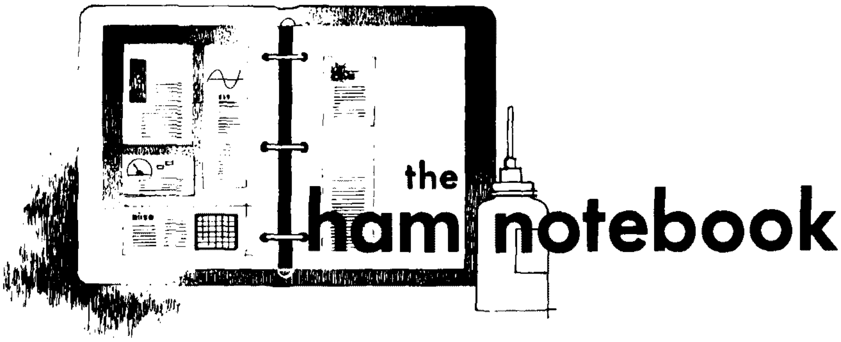
SEPTEMBER 8: The 20th anniversary of "Howdy Days", starts Wednesday, September 8, 1800 UTC to Friday, September 10, 1800 UTC. All licensed women operators worldwide are invited to participate. Say hello to old friends; meet new ones. Extend an invitation to non-members to join YLRL. Call "CQ YL". All bands and modes of emission may be used. No cross band operation. Send logs by October 11, 1982, to: Sandi Heyn, WA6WZN, 962 Cheyenne St., Costa Mesa, CA 92626.

September 11: KNØS will operate from 1300-2200Z to commemorate the 4th annual Burnsville Fire Muster. Frequencies: 7.250, 14.340, 21.400 ± 5 kHz phone. 7.125 CW in AM. 146.16/.76 locally FM. For a special certificate send large SASE to: KNØS ARS, PO Box 23349, Richfield, MN 55423-0349.

SEPTEMBER 25: The Beaumont, Texas, ARC will operate W5RIN from 1700Z-2300Z, September 25 and 26 during the "Glady's City Boom Days" 81st anniversary of Spindletop, home of the Lucas Gusher. Frequencies: phone - 21.280, 14.280, 7.280. CW - low 25 kHz of Novice 10-15-40 meter band. For certificate and brochure on the history of Spindletop send large SASE to: BARC, PO Box 8358, Lumberton, TX 77711.

OCTOBER 9: The Coosa Valley ARC will operate from Rome, GA, from 1200Z, October 9 to 2200Z, October 17 to commemorate Heritage Days. 25 kHz lower side of General Class phone band 80 - 10 meters. For a special certificate SASE to: CVARC, Box 183, Rome, GA 30161.

OCTOBER 12: The Colquitt County Ham Radio Society will operate club station, WD4KOW, from the site of the fifth annual Sunbelt Agricultural Exposition, October 12, 13 and 14, 0900 to 1700 EDST each day. Operations in the General portion of the HF bands. Club members will be listening for visiting Hams on local repeater 146.19/79. For a special QSL SASE to: Colquitt County Ham Radio Society, PO Box 813, Moultrie, GA 31768.



inductive reactance controls fan speed

Living in Florida as I do, I find that temperatures in the shack can rise quickly in summer, particularly when I'm running a linear. Some kind of cooling is desirable. Using a large window fan to cool the shack, I found, had two drawbacks. First off, it was a single-speed type, and just a bit too fast — always blowing papers all over the place. And secondly, as it got older, it developed an annoying rattle at its normal speed.

When I experimentally slowed down the speed of the fan with my Variac, I got both less air blowing around, and the rattle completely disappeared. Not wanting to tie up my very useful Variac for this purpose, I thought up other ways of reducing the fan voltage and speed.

A voltage-dropping resistance would do the job, but resistance dissipates both heat and uses expensive energy. Why not use a reactance to cut down the voltage? I tried first an inductive reactance and then a capacitive reactance. Although both kinds worked, I decided to use an inductive reactance. This was because, when experimenting with capacitors of various sizes for slowing down the fan, I ran into an interesting condition. At some values of capacitance, the capacitive reactance partially cancelled the inductive reactance of the fan, and the fan actually started to run quite a lot faster than its normal speed. So, to avoid problems, I decided on an inductive reactance to slow the fan down. I found that using the secondary winding of an old filament transformer provided enough reactance to slow the fan to the speed I desired.

William Vissers, K4KI

novel two-tone signal generator

For experimentation and tuning up, a two-tone generator is surely a desirable piece of equipment to have. But being lazy by nature and not too good at building test equipment, I wanted to come up with a simple substitute method.

Like many other Amateurs, I like music and have a Hammond organ. A check with my scope showed that the upper and lower manuals both readily provide a very good sine wave if only one organ stop per manual is pulled out. It was simple to use a couple of variable resistance potentiometers to mix the two tones to the proper level for the audio signal to my transceiver. The tone voltages from the organ can be picked off directly from the output speakers, or at some lower level by tapping into the organ circuitry.

I will admit that this is probably the largest two-tone generator in existence, but it does a very satisfactory job. And for Amateurs who do not have their own organs, I found that it is very easy to put the two tones on a small cassette recorder tape. Several Amateurs have come over and done this using their own tapes, which they now use instead of building a tone generator of their own. So you save money and time by using something you already have, instead of building a piece of test equipment that you will use only a very small percentage of your operating time.

William Vissers, K4KI

cheap dots

I use black dots when making up printed circuit boards, and they are very expensive: $4.00 per one hundred dots. The reason is that they are precision drafting aids. Recently I found in a stationery store that you can buy black dots that work just as well, manufactured by the Avery Company or Dennison. Ask the stationer to show you his catalog and you might also see tapes that you can use with the dots. I find that it is cheaper to use shelf paper and cut it out with a razor. It makes a sharp image when etched and the acid does not sneak under it, the way it will with black masking tape.

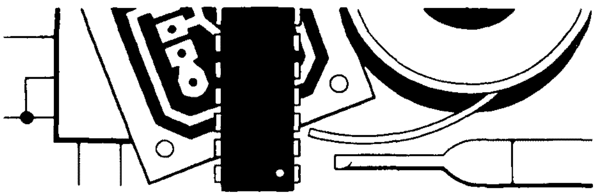
Ed Marriner, W6XM

decreasing dust buildup

In line with extending the life of my Yaesu FT-101-B transceiver, I have found that dust pulled into the unit by the cooling fan becomes a real problem over an extended period of time. And as I do spend a great deal more time listening than transmitting, I rigged up a simple switching circuit that cuts off the cooling fan when the transceiver amplifier filaments are turned off. There is no noticeable rise in temperature when operating like this. You keep your equipment a lot cleaner this way. And, naturally, a dust cover is a must for all equipment when the station is shut down. Clean equipment will break down a lot less often than equipment coated inside with dust, which, by absorbing moisture, can cause severe corrosion and expensive breakdowns.

William Vissers, K4KI

the weekender



precision battery-voltage monitor for HTs

How often has your HT signal become heavily distorted, or even entirely unreadable, because of dead batteries? With an accurate voltage monitor to flag you before your Ni-Cds die, you can avoid such incidents. And you also gain the peace of mind of knowing that your weak or distorted signal is, in fact, due to your batteries — and not some other cause. The monitor described here is easy to build and adjusts to any battery voltage. It draws about 0.25 mA and consists of only four parts.

The heart of the circuit is a precision voltage-monitor chip produced by Intersil, the ICL8211CPA. This eight-pin miniDIP contains a temperature-compensated voltage reference and other circuitry to make up the basics of a voltage monitor. Because of its CMOS design, the chip is eminently suitable for an rf environment, and it draws only 22 microamperes. Adding a pot, resistor, and LED completes the monitor circuit.

By Alan Lefkow, K2MWU, 17 Jacobs Road, Thiells, New York 10984

Fig. 1 is a schematic of the monitor. A ten-turn pot, R1, divides down the battery voltage to match the built-in reference voltage of IC1 (1.15 volts). When the voltage at pin 3 falls below 1.15 volts, pin 4 of IC1 supplies a constant current of 7 mA, enough to drive a small LED directly. A 2.0-megohm resistor, R2, is used to provide a small amount of hysteresis, an option provided for by IC1. Without hysteresis, the LED could flicker on and off when the monitored voltage varies around the set point, as might be the case on voice peaks during receive. About 0.2 volt of hysteresis is added with R2. Thus, if the monitor were set to trip at a voltage of 10.0 volts, it would turn off when the voltage rose above 10.2 volts.

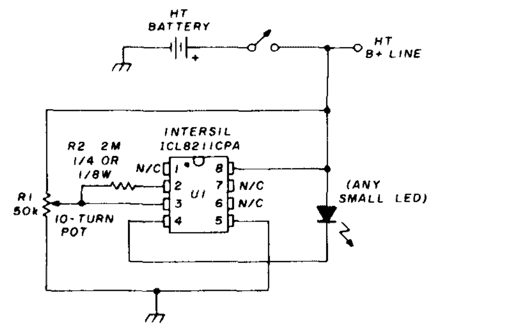


fig. 1. Schematic diagram of the battery-voltage monitor.

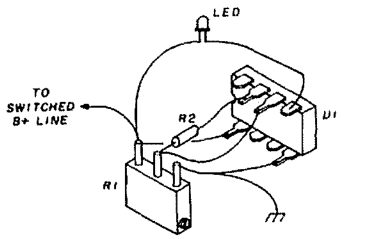


fig. 2. A 3/8- or 1/4-inch square pot for R1 produces a compact package. The leads of the IC are soldered directly to the pot and to R2. A stiff ground lead can support the whole circuit.

For absolute compactness, the parts are wired together using the pins and leads of the parts themselves, as shown in **fig. 2**. In the author's HT, a Wilson Mk II, the ground wire supports the whole circuit. The LED can be placed anywhere convenient and connected to the circuit with thin wires. The monitoring point (which is also the B+ supply for the circuit) is best picked up just after the HT's ON/OFF switch.

Determining the desired trip point is not difficult. Generally, Ni-Cd batteries are close to the end of their discharge capacity when the voltage per cell falls below 1.2 volts. At 1.1 volts per cell there's about 5 percent capacity left, and at 1.0 volt per cell, the battery can be considered discharged.[1] A convenient trip point, therefore, is 1.1 volts per cell.

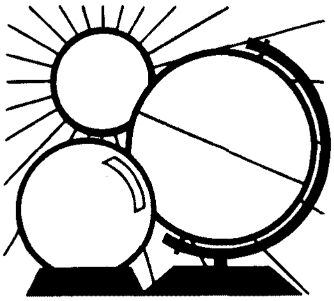
Recharging at that point on a regular basis will not cause memory to set in, and allows for a few more minutes of use before the battery voltage really starts to plummet. Hence, if your battery pack has, say, nine cells, the trip point for the monitor would be 9.9 volts. (You can figure out the number of cells your pack contaihs by dividing its nominal output voltage by 1.2.) Your rig may run on less than 1.1 volts per cell, but to do so entails the risk of reversing voltage on one of the cells, which can kill a battery pack.

The trip point is easily set using an adjustable power supply and DVM. Adjust the pot until the LED turns on at the desired battery voltage, using the power supply as an adjustable source for the HT. The circuit is accurate enough to make use of the greater resolution and accuracy of a DVM. In the author's rig, the monitor was originally set to trip at 9.9 volts. A recent test showed the trip point still at 9.9 volts, three years later!

reference

1. *Nickel Cadmium Battery Handbook*, General Electric, 2nd Edition

ham radio



DX FORECASTER

Garth Stonehocker, KØRYW

last minute forecast

Another equinox season is here with its special propagation features. Features to note are these:

- Trans-equatorial one-long-hop openings on the higher frequency bands during geomagnetic disturbances;
- Trans-polar openings (gray-line DX) near twilight on the lower frequency bands during quiet geomagnetic periods between disturbances;
- High ionospheric electron densities giving high maximum usable frequencies (MUFs) favoring long-skip DX on the high bands;
- Some sporadic E layer openings, mainly near twilight for the lower bands;
- Geomagnetic disturbances increase, moving the ionosphere around, creating DX openings in unusual locations and providing an auroral curtain to reflect east/west paths by VHF-auroral scatter.

More detail on equinoctial propagation can be found in the March, May, and September columns of *ham radio* beginning in 1981.

The forecast for September emphasizes that the upper frequency bands (10, 15, and 20 meters) will be excellent for DX during the middle of the month. These ham bands will probably begin to feel the solar flux effects of the eleven-year sunspot cycle, decreasing to an expected 100 or so (150 solar flux units). The beginning and ending weeks will be the worst, these time periods being closest to the 27-day solar cycle minimums. The lower frequency bands (40 through 160 meters) should be very good throughout the month. Overall, average thunderstorm QRN should decrease in the Northern Hemisphere, except for localized QRN, which builds up a day before and a day after a thunderstorm's passing, and while the storm is within sight of your QTH.

The full moon will occur on September 3rd; the moon perigee will occur on the 13th. The autumnal equinox will be on the 23rd at 0846 UT. No significant meteor showers are expected, so activity may be quite mediocre for the meteor-burst DX work.

Last month I presented a formula for determining northern latitude radio quality. It may also be used as a base-line quality number from which you can make your own calibrations to fit your operations. A typical base-line calibration for north Atlantic paths is shown in **table 1**.

table 1. Base-line calibration for North Atlantic paths.

0 - 1.50	useless
1.51 - 2.50	very poor
2.51 - 3.50	poor
3.51 - 4.50	poor-to-fair
4.51 - 5.50	fair
5.51 - 6.50	fair-to-good
6.51 - 7.50	good
7.51 - 8.50	very good
8.51 - 9.50	excellent
9.51 up	unbelievable?

Radio propagation quality (QRK) seems to be made up of signal strength (QRA) and its variability (QSB) factors. The formula uses tne radio flux and sin^2X values for the signal strength factor. The variability factor is tied into the geomagnetic A value. A fairly reasonable estimate can be calculated using these assumptions. Give it a try at your station if you've a programmable calculator or computer available.

band-by-band summary

Ten and fifteen meters will be loaded with good DX signals from morning until the early evening hours on many days. Periods of geomagnetic disturbance will limit the number of signals heard, but listen carefully — they can be from very unusual places. Fifteen meters should be open later in the day, after 10 meters, so, hit 10 first and finish off with 15.

Twenty meters will be the main daytime DX band, as it is almost always open to some part of the world. It opens in the east as the sun rises and extends into the late evening hours in the west. Geomagnetic disturbances do not affect this band as much as the higher ones, but look for unusual trans-equatorial DX locations that will come through once in a while. One-hop trans-equatorial DX of 5,000-7,000 miles (8,000-11,200 km) may be possible in the late evening hours during some of these unusual conditions.

Forty and eighty meters will have good short skip during daylight hours and turn to DX after dark. The bands will open in the east soon after sundown, swing toward the south to Latin America about midnight, and end in the Pacific areas during the hour or so before dawn. Some nights these bands will be as good as can be expected during the winter DX season, coming up from November-February. The coastal regions usually have the edge for working the rare DX on these bands.

One-sixty meters will be quieter (QRN) now. This band should have renewed DX possibilities with LORAN phased out and privileges restored.

ham radio

SEPTEMBER

WESTERN USA

GMT	PDT	N (Asia, Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania, Australia)	NW (Japan)
0000	5:00	10	—	15	15	—	10	10	10
0100	6:00	10	—	15	15	15	10	10	10
0200	7:00	10	—	20	15	15	10	10	15
0300	8:00	15	—	20	15	15	10	10	15
0400	9:00	20	—	20	20	15	15	10	15
0500	10:00	20	—	20	20	20	15	10	20
0600	11:00	20	—	20	20	20	15	15	20
0700	12:00	—	—	20	20	20	20	15	20
0800	1:00	—	—	20	20	20	20	15	20
0900	2:00	—	—	—	20	20	20	20	40
1000	3:00	—	—	—	20	20	20	20	40
1100	4:00	—	—	—	—	—	20	20	20
1200	5:00	—	—	—	—	—	20	20	20
1300	6:00	—	20	—	—	—	40	20	20
1400	7:00	20	20	—	—	—	40	—	40
1500	8:00	20	15	15	10	20	—	—	20
1600	9:00	20	15	15*	10	20	—	20	20
1700	10:00	20	15	10	10	15	—	20*	20
1800	11:00	20	15	10	10	15	10	—	—
1900	12:00	20	15	10	10	15	10	—	—
2000	1:00	20	15	10	10	15	10	10	—
2100	2:00	—	15	10	15	15	10	10	10
2200	3:00	—	20	10	15	15	10	10	10
2300	4:00	—	20	10	15	15	10	10	10

MID USA

GMT	MDT	N (Asia, Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania, Australia)	NW (Japan)	CDT
0000	6:00	10	20	15	10	—	10	10	10	7:00
0100	7:00	10	—	15	15	15	10	10	15	8:00
0200	8:00	10	—	20	15	15	15	15	15	9:00
0300	9:00	15	—	20	20	15	15	15	15	10:00
0400	10:00	15	—	20	20	20	15	20	20	11:00
0500	11:00	20	—	20	20	20	20	20	20	12:00
0600	12:00	20	20	20	20	20	20	20	20	1:00
0700	1:00	20	—	20	20	20	20	20	20	2:00
0800	2:00	20	—	20	20	20	20	20	20	3:00
0900	3:00	—	—	20	40	20	20	20	20	4:00
1000	4:00	—	—	—	40	20	20	20	20	5:00
1100	5:00	—	20	—	—	—	20	20	20	6:00
1200	6:00	—	20	—	—	—	20	20	—	7:00
1300	7:00	20	15	—	—	—	20	—	—	8:00
1400	8:00	20	15	10	—	—	20	—	—	9:00
1500	9:00	20	15	10	10	—	—	20	—	10:00
1600	10:00	20	15	10	10	—	—	20*	—	11:00
1700	11:00	15	15	10	10	15	—	—	—	12:00
1800	12:00	15	15	10	10	15	10	—	—	1:00
1900	1:00	20	15	10	10	15	10	—	—	2:00
2000	2:00	—	15	10	10	15	10	10	—	3:00
2100	3:00	—	15	10	10	15	10	10	10	4:00
2200	4:00	—	20	15	10	15	10	10	10	5:00
2300	5:00	—	20	15	10	15	10	10	10	6:00

EASTERN USA

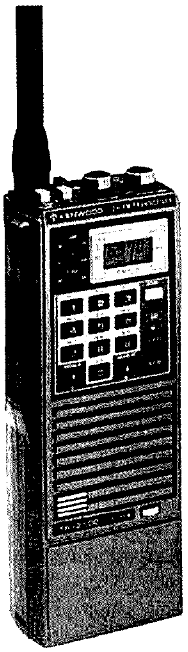
GMT	EDT	N (Asia, Far East)	NE (Europe)	E (S. Africa)	SE (Caribbean, S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania, Australia)	NW (Japan)
0000	8:00	10	20	15	15	20	10	10	10
0100	9:00	15	20	15	15	20	10	10	15
0200	10:00	15	40	20*	20	20	10	15	15
0300	11:00	20	40	20	20	20	15	15	20
0400	12:00	20	40	20	20	20	15	20	20
0500	1:00	20	—	20	20	20	20	20	20
0600	2:00	—	—	20	20	20	20	20	20
0700	3:00	—	—	20	20	20	20	20	20
0800	4:00	—	—	20	20	20	20	20	20
0900	5:00	—	20	—	20	20	20	20	—
1000	6:00	—	20	—	20	—	20	—	—
1100	7:00	20	20	—	20	—	20	—	—
1200	8:00	20	15	10	20	—	—	—	—
1300	9:00	20	15	10	20	—	—	—	—
1400	10:00	20	15	10	10	—	—	15	—
1500	11:00	15	15	10	10	—	—	15	—
1600	12:00	15	15	10	10	15	—	20	—
1700	1:00	15	15	10	10	20	—	20	—
1800	2:00	15	15	10	10	15	—	20	—
1900	3:00	—	15	10	10	15	10	10	—
2000	4:00	—	20	10	10	15	10	10	—
2100	5:00	—	20	10	10	15	10	10	10
2200	6:00	10	20	10	10	15	10	10	10
2300	7:00	10	20	15	15	15	10	10	10

*Look at next higher band for possible openings.

NEW products

TR-2500

Trio-Kenwood Communications announces the new TR-2500, a compact 2-meter fm handheld transceiver. The TR-2500 weighs approximately 1.2 pounds yet includes such features as LCD digital frequency display, ten-channel memory with memory scan, built-in five year lithium memory back-up, manual scan, programmable automatic band scan, built-in tunable subtone encoder, built-in sixteen key auto-patch encoder, and 2.5 watts rf output with HI/LO power output switch.



Complete with rubberized antenna with BNC connector, 400-mAH heavy-duty NiCd battery pack, and ac charger, the TR-2500 has a factory suggested retail price of only $329.95.

For additional information, contact Trio-Kenwood Communications, P.O. Box 7065, Compton, California 90224.

micro-based repeater controller

The RC-850 Repeater Controller is a microcomputer based control system remotely configurable by the owner, with TouchTone™ commands. No hardware or software changes are required.

Remote configurability enables repeaters to be customized without trips to the site, and eliminates dependence on the manufacturer to make changes over the life of the repeater. Configuration parameters are stored in a non-volatile memory which requires no batteries for data retention.

The RC-850 controller's autopatch is based on a store and forward technique — the controller dials numbers into the phone, using TouchTone or dial pulse. Phone number readback helps prevent wrong numbers and allows the control operator to monitor autopatch activity. The user-loadable autodialer speeds dialing of home phone numbers. The emergency autodialer reads back a configurable message for each location, to verify selection of the correct emergency autodial location.

Voice-response telemetry provides remote monitoring capability. A natural sounding speech synthesizer, analog measurement capability, plus configurable meter faces permit readback of user's S-meter, frequency error, or deviation readings, plus power, temperature, and other parameters using external transducers. Users can receive diagnostic information about their signals, and you can remotely monitor your equipment and your site.

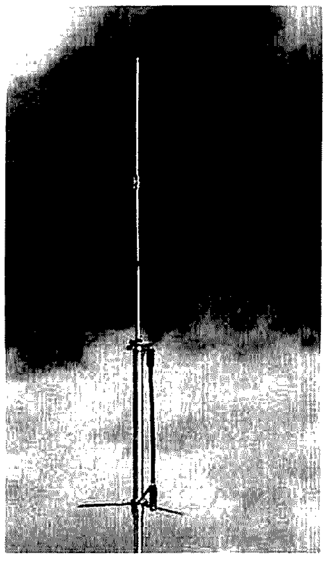
The synthesized remote base capability permits linking to other machines and simplex channels, to extend coverage area or pick up additional operators during emergencies and public service activities. The low power consumption, single supply operation simplifies power backup, and maximizes endurance when commercial power is lost.

Audio processing, including an analog delay line, mutes squelch tails on received signals. TouchTone is also muted — not even a blip of tones gets through. No more annoying double squelch tails and screeching tones.

For more information, contact Advanced Computer Controls, 10816 Northridge Square, Cupertino, California 95014; telephone 408-253-8085.

base station antenna

The Ringo Ranger II has 5.5 dB gain with an additional 5/8 wave section and decoupling radials for a low angle of radiation. Ringo Ranger II antennas are broadband and easily field tuned for quick installation. They are made from the highest quality aluminum, with stainless steel hardware. They cover frequency ranges from 146-512 MHz.



For more information, contact Cushcraft Corporation, P.O. Box 4680, Manchester, New Hampshire 03108; telephone 800-258-3860.

3-band package for vacationing hams

Dentron Radio Co. has introduced a 3-band 25-watt CW transceiver and accessory package designed to help the Novice learn CW operation or to allow the experienced ham to keep in touch when he's away from a traditional power supply. It will run off any 12 Vdc battery. The transceiver covers 80, 40, and 15 meters and will receive SSB as well as CW. The complete package includes a code key, 3-band dipole antenna, head set, log book, an ARRL license manual, and a complete radio and code course on cassette tape. Optional accessories include a 120 Vac power supply with built-in speaker and antenna tuner.

For more information, contact Dentron Radio Co., Inc., 1605 Commerce Drive, Stow, Ohio 44224; telephone 216-688-4973.

morse code and teletype reception

Commsoft's Cipher89 is a receive-only program for Morse code and radioteletype transmissions. The program features Baudot and ASCII operation up to 1200 baud and Morse code operation from 4 to 99 WPM.

NEW products

Cipher89 is heavily graphics oriented with many on-screen menus to help the listener identify the format and natures of received messages. Histogram and map modes can be used to correlate data against previous intercepts and to identify the use of encryption.

The program comes with an instruction manual containing chapters covering many aspects of shortwave listening. An audio cassette tape, containing recordings of many types of signals the shortwave listener will encounter, is included.

Cipher89 requires a Heath H-8/H-19 or H-89 computer with 32K of RAM and one disk drive. The program runs under the Heath Disk Operating System (HDOS). In addition, a hardware interface, such as the Commsoft Codem, is required to connect the shortwave receiver to the computer.

The price of the package is $99.95. A combination package, which includes the program plus a Codem, interconnect cable and power supply is available for $249.95. For more information, contact Commsoft, Inc., 665 Maybell Avenue, Palo Alto, California 94306; telephone 415-493-2184.

multi-site repeater voting system

Heil Sound has developed a repeater voting system, the VT-3, designed to work with three remote receivers using a UHF radio link between receiver and transmitter sites. The equipment is designed around a delay board that measures the strength of incoming receiver signals. Activation of the link transmitter depends on the strength of the signal. The stronger the signal, the faster the link equipment is turned on. The first link signal heard enables the transmitter latch board, locking out other receivers. Audio from the receiving link is fed through an active audio equalizer so that audio loss is regained.

Only an external timer from the transmitted latch board and the ID system is needed to use the system. Each receiver delay board and transmitter latch board have dc switching to operate all keying lines.

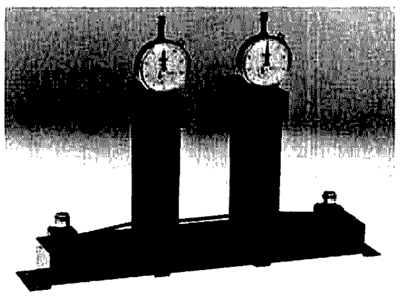
The complete kit, all boards and components for three receivers and one transmitter site, is available for $82 plus $3 shipping and handling.

For more information, contact Heil, Ltd., Heil Drive, Marissa, Illinois 62257.

terrestrial frequency analyzer

The Model 4043 Terrestrial Tracer is a tunable, calibrated wavemeter for diagnostic evaluation of TVRO system terrestrial interference in the 3.7-4.2 GHz band. The tunable notches (approximately 20 dB deep) can be adjusted to obtain best system performance while viewing a transponder which displays symptoms of interference. When best performance is obtained, the calibrated indicators can be used to determine the terrestrial carrier frequency. Then, a permanent microwave notch filter can be fabricated to remove the offender.

The 4043 is installed in the signal

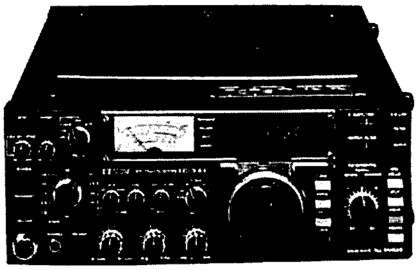


path between the LNA and the downconverter. The unit passes dc for supplying power to the LNA. The 4043 costs $790.00.

For more information, contact Emily Bostick, Microwave Filter Co., Inc., 6743 Kinne Street, East Syracuse, New York 13057; telephone (in U.S.) 1-800-448-1666.

versatile transceiver

The IC-740 transceiver has front panel or top controls allowing convenient access to all operating functions. Adjustable receiver parameters are: rf preamp, rf gain, noise blanker



(width and level) i-f shift, passband tuning, crystal filter in/out, notch filter, AGC (time constant and on/off), squelch, tone, and audio gain. Transmitter controls are mic gain, VOX, compressor and power (10-100 watts). The IC-740 includes capability of operating in the increasingly popular fm mode.

The IC-740 features dual VFOs with three tuning rates, split operation and memory. Analog control of frequency with the incremental tuning works on TX and RX. You are able to meter receive signal strength, transmit relative rf output, compressor level, ALC and collector current plus a built-in SWR meter.

A large selection of options are available. All items are compatible with the IC-740, including the popular AT-500/100 automatic antenna tuner, as well as the IC-2KL solid-state linear.

For more information, contact ICOM America, Inc., 2112 116th Avenue, N.E., Bellevue, Washington 98004; telephone 206-454-8155.

digital multimeter

Beckman Instruments, Inc., has expanded its line of digital multimeters. The attention-getting DMM is called the Tech™ 320B digital multimeter and has both audible and visual indication of continuity. When it's not possible to see the large LCD, the meter will alert the user when continuity is detected by emitting a single, loud beep. Continuity is also visually displayed (in less than 1/10 of a second) by the appearance of an ohm sign in the upper left corner of the LCD.

Like other Beckman portable DMMs, the Tech 320B features an easy-to-use single center selector switch, 0.1 percent basic Vdc accuracy, 10-ampere ac/dc current ranges, 2,000-hour battery life from a standard 9-volt battery, semiconductor test function, and overload protection on all ranges.

The Tech 320B has twenty-nine ranges and is protected against overload. Voltage ranges are protected to 1,500 volts dc or 1,000 volts RMS ac.

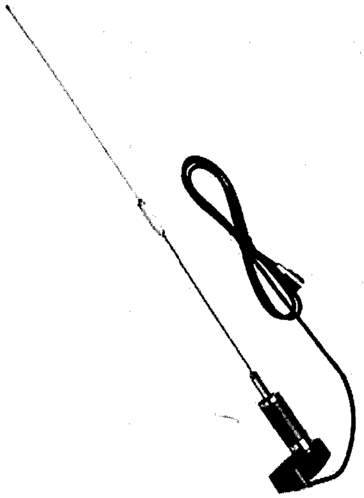
NEW products

All resistance ranges are protected to 500 volts RMS, and current ranges are 2A/250V fuse protected — a spare fuse is included. The 10-ampere ranges are rated up to 20 amps for 30 seconds.

Suggested retail price is $189. For more information, contact Beckman Instruments, Inc., 210 Ranger Street, Brea, California 92621; telephone 714-993-8803.

UHF Amateur antenna

Hustler, Incorporated has announced a mobile trunk lip-mount colinear antenna for 438-450 MHz Amateur service. Model BBLT-440 has a unique 5/8-wave design that develops a 5 dB gain, compared to a quarter wave stub, and features a 10 MHz bandwidth with under 2:1 VSWR.



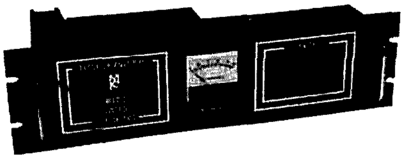
The moisture-sealed impedance transformer features silver plated base to coil contacts and 15 feet of ultra low-loss coaxial cable with connector.

For additional information, write Hustler, Incorporated, 3275 North B Avenue, Kissimmee, Florida 32741.

repeater power amps

A new line of continuous-duty power amplifiers for repeater service has been introduced by Micro Control Specialties. Three different models in the new PA-75 series serve the popular repeater frequencies of 144-148, 220-250, and 420-450 MHz.

Each model in the new PA-75 series provides 75 watts output with 10 to 15 watts of drive from a repeater or base station. The PA-75 also includes a three-section harmonic filter, ac power supply, front panel fuse access, and metering in a handsome rack mount package.



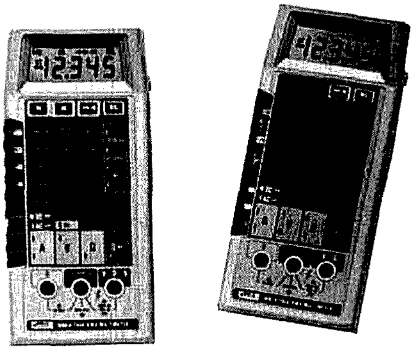
Dependable continuous-duty operation is obtained by using a generous heat sink plus a quiet axial fan arranged to cool both amplifier and power supply components. In addition, efficient 28-volt transistors are used for high reliability and long life.

For further information write to Micro Control Specialties, 23 Elm Park, Groveland, Massachusetts 01834; telephone 617-372-3442.

handheld 4½-digit multimeter

Fluke's 8060A is a handheld, microcomputer-based 4½-digit multimeter that includes true RMS measurements for ac signals to 100 kHz, frequency measurements to 200 kHz, resistance measurements to 300 megohms, and can store any measurement as an offset value. Voltage measurements can be directly displayed in dBm referenced to 600 ohms, or in relative dB. Continuity testing (with selectable visual/audible indication), conductance, and constant current source diode testing are

NEW products



also included. A multiplexed LCD display provides special function annunciation, low battery (twenty percent) warning, and a power-up self-diagnostic indication.

The Fluke 8060A is powered by a standard 9-volt alkaline battery (170 hour continuous operation) or op al ac battery eliminator. The 806 priced at $349, the 8062A, a corr ion model without the Hz, dB conductance functions, is $279.

For more information, cor John Fluke Mfg. Co., Inc., P.O. C9090, Everett, Washington 98206; telephone 206-342-6300.

1:1 balun antenna

Hustler, Inc., offers a 1:1 balun hf Amateur antenna. The balun, model BLN, features a low-loss air core design that eliminates saturation at high power levels while maintaining a uniform power balance in the system. It is rated at 1 kW, and has a bandwidth of 7 to 35 MHz. The stainless steel

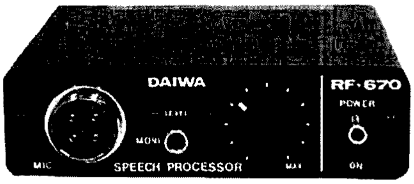
hardware and flying leads are supplied for connection to the driven element of beams, quads, or dipoles. Coax termination is to an SO-239 connector.

For additional information, contact Hustler, Inc., Sales Department, 3275 North B Avenue, Kissimmee, Florida 32741.

Daiwa RF-670 speech processor

Daiwa announces a compact audio speech processor that rivals the performance of the rf types at an economical price. The RF-670 will give your signal the boost it needs to cut through QRM. The unique photocoupler design delivers a high level of processing with a minimum of distortion.

Traditional audio processor design is handicapped by the circuitry time constants that limit the ability of the



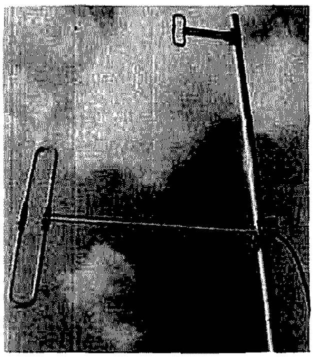
processor to respond to rapid variations in the level of the input audio signal. The result is distortion and poorer performance. The RF-670's photocoupler/variable gain amplifier design permits a very rapid response to input levels, and the result is clean output and excellent performance. The RF-670 features velcro pads for easy mobile or base mounting.

For more information, contact MCM Communications, 858 E. Congress Park Dr., Centerville, Ohio 45459; telephone 513-434-0031.

base station antenna

Sinclair Radio Laboratories have introduced a new VHF/UHF combination base station antenna for mobile communications systems. Called the

310/210, the antenna uses one SRL-210 and one SRL-310 exposed dipole. The 310/210 offers exceptional bandwidth and efficient coverage for both



the 138-174 MHz and 406-512 MHz frequency ranges.

This extremely rugged antenna has been designed with the needs of the service shop in mind. The two dipoles are mounted on a 10-foot mast of 1½-inch ISP-schedule aluminum pipe. The 310 dipole is secured to the mast while the 210 dipole is left unassembled for shipping. The antenna can be easily transported and quickly assembled for an on-site test or demonstration.

Both dipoles are spaced one-half wavelength from the mast. This provides a nominal gain of 2 to 2.5 dB in an essentially omnidirectional pattern. VSWR across the full bandwidth is 1.5:1 or better. The 210 dipole can handle 200 watts; the 310 is rated at 75 watts. With half-inch radial ice, the rated wind velocity is 85 MPH. Both dipoles are at dc ground potential for maximum lightning protection.

For further information, contact Sinclair Radio Laboratories, Inc., 14614 Grover Street, Suite 210, Omaha, Nebraska 68144; telephone 800-228-2763.

automatic SWR meter

Palomar Engineers introduces the M-827 SWR meter which computes SWR automatically and displays it on a light bar. The SWR reading is always correct regardless of power level, and the light bar follows changes instantly. A second light bar displays power. It follows with the speed of light so you can see all the SSB peaks.

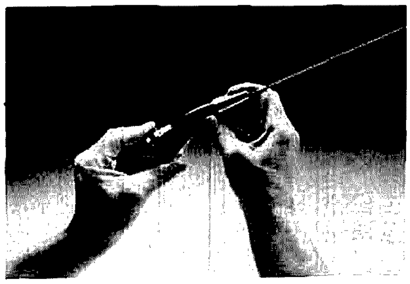
The frequency range of the M-827 SWR meter is 1-30 MHz. The SWR scale is 1 to 10 with a logarithmic response that gives much improved resolution where you need it.

The M-827 SWR meter sells for $97.50. For further information, write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025.

shock mount antenna

Antenna Specialists Co. introduces a new line of professional mobile communications antennas designed around a new concept in shock mounting, called Dura-Flex. In place of the conventional steel shock spring, the antenna is equipped with a tapered, cylindrical shock mount of molded neoprene which performs the basic shock-absorbing function while solving two special problems experienced in several mobile environments.

A/S engineers discovered the high noise levels were being generated in spring-equipped antennas by interaction of metal spring coils, which normally carry a small amount of rf. This



problem is especially noticeable with slightly corroded springs. The solution was to use neoprene along with a material capable of withstanding pounding, flexing, and extremes of temperature. The whip and base mount are mechanically interconnected by means of solid brass threaded connectors totally sealed

NEW products

within the shock mount. The connecting braid is totally isolated from the mount through an interior cavity and thus not subject to any strain from deflection. The mount is completely waterproof and may easily be removed.

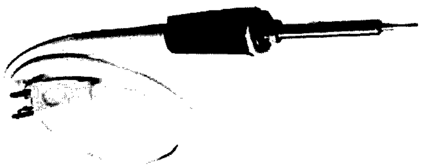
Dura-Flex-equipped antennas are available in standard roof, trunk lid, cowl, and magnetic mounting configurations at high band and UHF frequencies. The ASP-1450 series, with 3 dB gain, is designed for 138-174 MHz. Three UHF series are offered: Model ASP-1790 (3 dB gain) for 445-512 MHz; Model ASP-1650 (a 5 dB-gain collinear) for 406-512 MHz; and ASP-1750 series (a deluxe 5 dB-gain collinear with low loss Pro-Flex cable). A 3 dB motocycle model, ASP-1791, and a no-ground-plane model, ASP-1751, both for UHF, also are available.

For complete technical details and specifications, write to Marketing Department, The Antenna Specialists Co., 12435 Euclid Avenue, Cleveland, Ohio 44106.

static-free soldering iron

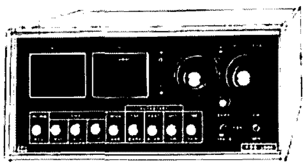
The system 9300 soldering iron uses Ungar's Thermo-Duric™ heating element, a non-magnetic iron which conducts static electricity from the tip to a grounded wall plug, preventing static electricity damage to microcircuits.

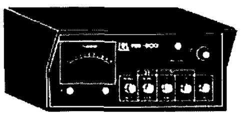
An operating temperature of either 700 or 800 degrees Farenheit is determined by the heater. Any of the five standard Ungar tips may be used with this iron.



Prices of the Model 9370, which is equipped with a 700 degree heater, and Model 9380, which comes with an 800 degree heater, are $27.97.

For further information, contact Ungar, Division of Eldon Industries, Inc., 100 West Manville Street, Compton, California 90220; telephone 213-774-5950.





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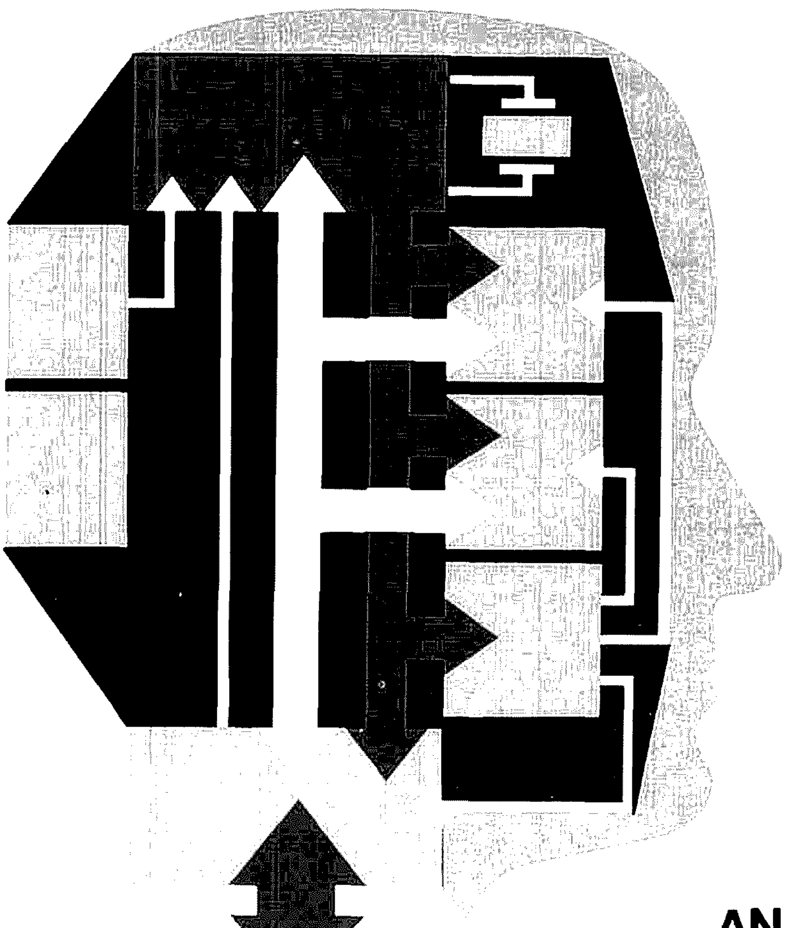

AN INTELLIGENT HAM GEAR CONTROLLER

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focus on communications technology

ham radio

magazine

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Observation & Opinion

Whatever your operating preference might be, it doesn't take much time spent tuning the present hf U.S. phone subbands to realize most are badly overcrowded. Tuning below the lower edge of most of these bands reveals relatively sparse activity by non-U.S. phone operators. This imbalance cries out for correction. The FCC addressed the problem in Docket 82-83, with Comments due in mid-August.

The Comments came in, and now it's up to the FCC to sort them out. The ARRL's proposed reallocation of the phone bands, representing as it does the views of more than a third of the U.S. Amateur population, will certainly have a strong influence on the Commission's final decision. It should be noted, however, that about a quarter of those who responded to the League's original petition on expansion (RM-3860) were not in favor of it, so support is certainly not unanimous. Briefly, the League's response to Docket 82-83 proposed:

band	extra	advanced/extra	extra-general
80	3.75- 3.775	3.775- 3.850	3.850- 4.000
40		no change	
20	14.15-14.175	14.175-14.225	14.225-14.35
15	21.2 -21.225	21.225-21.3	21.3 -21.45
10	28.3 -29.7 for all three classes		

Whatever your feelings on expansion, the ARRL proposal is well thought-out and sound. The disagreement noted thus far has been in detail rather than principle, with one important exception: the League's Canadian Division (CRRL) has very strongly opposed U.S. phone band expansion, for obvious reasons. Their natural opposition has put the League in a difficult position with its Canadian members. Strong disagreement, though of a less formal nature, was also registered by a number of IARU societies from around the world. In the final decision, however, the FCC must act to benefit the Amateurs of this country, with the interests of those overseas a minor consideration.

On the DX phone bands the trend has been toward more and more overseas Amateurs operating in the U.S. phone allocations. On the higher frequencies one rarely hears a DX station other than a DX-pedition operating in the so-called "foreign phone band" announce he's listening in the U.S. band for a response, though it's still common on 40 and 75. Of course there's still a lot of DX-DX and DX-VE phone action on frequencies we can't use, but almost without exception, that could be taking place in a narrower spectrum without reaching anything resembling the level of congestion that afflicts the U.S. 20-meter phone band on a Sunday afternoon.

Though the ARRL's suggestions will carry much weight at the Commission, theirs is not the only voice that will be heard. Comments on the expansion docket were submitted by many other groups and clubs as well as individual Amateurs, and it seems almost certain that most will differ in at least some details from those of the League. Let's take a look at some possible problem areas on a band-by-band basis.

80 Meters: This is the band most likely to cause our Canadian neighbors problems, since they are already sandwiched between U.S. phone and the heavy Novice plus RTTY and CW low-end activity. It is not unlikely that the proposed expansion of 75 phone will trigger a corresponding downward move in Canadian phone allocations, with some disruption of present non-phone 80-meter users.

40 Meters: Only the most dedicated 40-meter phone buffs seem to favor any expansion on this crowded band. Any downward shift in the U.S. phone allocation here would severely impact what is probably the most popular Novice band. Leaving 40 as-is makes great sense.

20 Meters: This is the band that most desperately needs more phone frequencies, and expansion down to 14.150 makes sense. What didn't make sense was the FCC's proposal to make the newly opened 50 kHz slot available to Generals, leaving a 75 kHz segment in the middle of the band that would still be off-limits to them. Perhaps the FCC put that in just to see if we were paying attention! Moving the current General Class 14.275 lower limit down, as in the ARRL submission, seems far more practical.

15 Meters: No problem is seen in moving U.S. phone down to 21.200. The 21.200-21.250 segment has never seemed to attract much foreign activity. The few foreign users that do want to avoid the expanded U.S. phone segment can still move a bit below 21.200 without problem, as the U.S. Novice activity on 15 meters seems to be pretty much at the bottom of the 21.100-21.200 Novice subband.

10 Meters: It's hard to see why the League felt the need to add another 200 kHz to a band that already has 1200 kHz of phone frequencies. The growing number of beacons in the underpublicized 28.200-28.300 10-meter beacon subband are going to become more important than ever in the coming years of low sunspots. Putting the lower edge of U.S. phone operations at the top of the beacon slot would certainly drive those foreign stations who do not wish to work the U.S. into the midst of the beacons. If expansion of 10 meters is needed at all, why not simply move the lower edge to 28.400 and leave a 100 kHz buffer for the beacon band? Furthermore, if incentive licensing is still considered a valid concept, why not make the new 28.400-28.500 segment an incentive subband?

In all the discussion of new phone frequencies, what about the long-suffering narrow-band mode enthusiast? What's in it for the CW or RTTY buff? Very little, at first glance. Fortunately, it seems most unlikely that the Commission would even consider encroaching on the lower band portions where these modes hold sway, seeing that the vast bulk of Comments filed on Docket 82-83 were along the order of the League's. In addition, we staunch users of those modes can look forward to an expansion of our own sometime soon, when the Senate and/or FCC finally decide it's time to catch up with much of the rest of the world and implement the new WARC 79 bands.

Despite the objections of non-U.S. Amateurs and the reservations of a minority from this country, a realistic appraisal of phone subband occupancy supports expansion. We are going to have some new phone frequencies in the near future. What they will be, who'll get to use them, and when they'll become available is now up to the FCC. We wish them good luck and Godspeed in their deliberations!

Joe Schroeder, W9JUV
associate editor

comments

power or voltage ratio

Dear HR:

N1AL's letter in the March, 1982, issue brought a needed correction concerning the third harmonic of a triangular waveform, but the latter part of the letter is in error. The usual definition of total harmonic distortion uses voltage ratios, whereas N1AL has given the figures for power ratios. So the distortion for a square wave is about 48 percent, for a triangle about 12 percent, and for the truncated triangle about 4.6 percent.

Bill Brandt, WB5DPZ/PR7ZAY
Brazil

WB5DPZ is correct; when expressed in dB, THD is normally given as a power ratio, but "%THD" implies a voltage ratio.

Alan Bloom, N1AL
Santa Rosa, California

who pays the jammer

Dear HR:

Psychology is the science of human behavior. Behaviorism is a very influential psychological school of thought which holds that organisms (rats, pigeons, human beings, jammers) repeatedly do whatever act is continually reinforced.

Put a hungry rat in a cage with a lever — eventually the rat will touch the lever. When he does, give the rat a food pellet. If you keep giving him food every time he touches the lever, very soon the rat will pump away on the lever until he is stuffed. Behavior (lever touching) get reinforced (food pellet) and becomes conditioned (habitual).

Parents do this with children: "Say please." "Please," and the child gets what he wants plus smiles and approval. He becomes conditioned to a lifetime of saying "please."

Why does someone jam for the first time? Why does the rat touch the lever the first time? Why does anyone first say "please?" Why doesn't matter, it happens and the behavior *is reinforced* so it happens again. The food pellet is easier to understand than the jammer, but the reinforcement principle applies.

The jammer gets attention, arguments, recognition, and he dominates whatever net or repeater he is on. *This is what he wants.* Why? Unimportant question: if he didn't want what he gets, he wouldn't keep jamming.

People who provide reinforcement generally take credit for the conditioning, "I taught a rat to press a lever," "I taught my child to say 'please'." Hams often argue with and counter-insult the jammer, thereby reinforcing the behavior. They are just as responsible for the results as the experimental phychologist or parent.

Any comment of any sort will let the jammer know he is successful and you are in for a long siege. Why does the jammer keep turning off his transmitter? He is listening for you to tell him he is successful. If you comment, no matter how rude or clever you may be, he will know he has been successful.

The only way to extinguish habitual behavior is to totally cut off reinforcement. Stop the food pellets and the rat will eventually stop pulling the lever. One careless food pellet will start the behavior again, more persistently. Say nothing on the air, roger for traffic you didn't copy, and carry on the conversation even if it is one-sided.

Do your detective work on the phone or a frequency you know the jammer doesn't monitor (is it the guy next to you at the club meeting? Complaining at a meeting is reinforcement).

If you have a persistent jammer it's your own fault: you get what you pay for.

Scott McCann, W3MEO
Annapolis, Maryland

DX and QRP

Dear HR:

Three hearty cheers for Alf Wilson's "Observation and Opinion" column, *ham radio*, April, 1982, regarding QRP DX. He hit it right on the TX button!

I was off the air for several years, so I've had a chance to witness the way the DX aspects of Amateur Radio have been evolving. I don't much care for some of what I see — and hear — but I am excited about what appears to be a growing interest in low-power DX.

Alf and I come from the same place: the land of big amplifiers, tall towers, and big antennas. I was a believer in the big signal. But, I returned to the air recently, after moving to W7. I got back on with 20 watts and a 5/8-wave vertical plus a terrible receiver. I never expected to work much DX, but, after six months, the total stands at 67. It can be done. As far as I'm concerned, the essence of ham radio is the experience and knowledge to be gained by building your own gear and operating it. QRP DX with homebrew combines it all, particularly when accompanied by observance of the etiquette and unwritten rules which seem to prevail in QRP DX. And, best of all, it doesn't cost an arm and a leg to get started.

The change I most regret in DX operating is the prevalence of operating habits which seem to have accom-

continued on page 79

presstop de W9JUV

RFI SANCTIONS ARE PURELY A FEDERAL MATTER under terms of the long awaited Amateur Radio bills (S.929 and H.R. 5008), passed by both houses of Congress in late August as part of the FCC authorization bill, H.R. 3239. It's on President Reagan's Western White House desk as this goes to press, awaiting only his signature to become law. To preclude Burbank (Illinois)-type confrontations, the House (Conference Committee) Report 97-765 stated:

"The Conference Substitute is further intended to clarify the reservation of exclusive jurisdiction to the FCC over matters involving RFI. Such matters shall not be regulated by local or state law..."

Amateur Exam Preparation/Administration And Use Of Amateurs as volunteer monitors were both included in the bill as it was passed. In the final version, Amateurs working the industry won't be able to administer exams, but will be able to work on their preparation. No such restrictions exist on monitoring, however. Furthermore, Amateur monitors will be empowered not only to detect and report apparent violations but may also be permitted to issue advisory notices (but take no other enforcement action).

10-Year License Terms For Amateurs and other non-broadcast services are also part of the new law, but the requirement for licensing both the CB and RC services was deleted. The bill also permits seizure and forfeiture of radio equipment used in violations.

The Many Worthwhile Benefits Of This Far-Reaching New Legislation also carry heavy responsibilities. Even before the bill was signed into law the Field Office and Enforcement Bureaus were already actively pursuing means to put its provisions into effect. Now that we have it, it's up to us to assume much of the task of making it work.

30-METER OPERATION BY U.S. AMATEURS IS CONSIDERED IMMINENT and could indeed have already come about by the time this sees print. An early August "Dear Mark" letter to FCC Chairman Fowler by Senators Goldwater and Schmitt advised him that Senate ratification of the WARC treaty could drag on into next year, and strongly urged the Chairman to provide U.S. Amateurs "immediate access" to the new 10.1 to 10.15 MHz band under Section 115 of the ITU regulations.

Chairman Fowler Promised The Senators the Commission would take up the question "in early fall " in his late August response, noting also "...I fully support early access by U.S. Amateurs to the 30-meter band." Such an action by the FCC could be accomplished quite quickly and simply with a Report and Order. Expectations are that any such "temporary" access to the new band would restrict users to narrowband modes (CW and RTTY) and less than maximum power levels.

6-METER FØ OPERATION HAS BEEN APPROVED by the FCC in a late August consent action. Acting on a Petition for Rule Making, the Commissioners agreed to add FØ to the modes permitted in the 51-54 MHz portion of the band.

The Report And Order On Digital Modes Was Set for Commission consideration at the first post-summer recess session in September, though it's considered likely that it will see a further delay. When the expected Notice of Proposed Rule Making on changes in Amateur rf power measurement will be out is still uncertain.

RICH ROSEN, K2RR, HAS JOINED HAM RADIO AS Associate Publisher and Senior Technical Editor. Rich's outstanding technical, editorial and Amateur Radio credentials will prove a very welcome addition in Greenville. Rich, formerly K2TXC, is an MS in EE whose professional background includes both hardware and propagation experience from VLF through 40 GHz. Most recently he was editor and later Associate Publisher of RF Design magazine; in addition he's an avid CW and phone contest operator who's been an active participant in the K2GL multi-multi contest team. Welcome aboard!

PROPER AMATEUR EXAM PREPARATION PAID OFF HANDSOMELY for Technician and General Class license applicants at a recent Baltimore FCC Field Office Exam session. Despite minor changes made in some of the exam questions and answers, 70% (the typical proportion) of those who'd prepared through club, school, or home study managed to make the grade.

Not So Lucky, However, Was A Group Who'd Just Finished one of the better known and highly promoted Q and A cram courses. Of this group, only 11% managed to write passing exams! The two groups could be easily distinguished, since those who'd used the cram course brought in Form 610s that had been supplied by its promoter.

MULTI-BAND OPERATION FROM THE WORLD'S HIGHEST BUILDING is scheduled for the October 16-17 weekend. The Fox River Radio League plans a two-station operation on 80-10 meter CW and SSB, as W9CEQ. Antennas will be at the 1454-foot level (110th floor) while the stations themselves will operate from the 103rd floor Observation Deck. Two-meter CW and SSB will also be used if conditions warrant; operating hours will be 1500Z Saturday through 2000Z Sunday. WD9GIG can provide further details.

THE U.S. AMATEUR POPULATION IS GROWING, and has been in recent years. In the early 50s, before the Novice and Technician licenses were introduced, it was around 50,000. By 1963 it had soared to over 250,000, but then (due perhaps to the imposition of license fees and/or incentive licensing) it became almost static for almost a decade. The mid-70s saw it start to climb again, until now (FCC July 30 figures) there are 404,534 individual Amateurs licensed in this country.

an intelligent ham gear controller: part 1

A computerized system that handles the operation of many equipment functions

Many good microprocessor components in the marketplace today are within the average builder's budget. Unfortunately, hams have been reluctant to build microprocessor circuits into their equipment, perhaps because of resistance to the technology or to changing from conventional to intelligent control.

This two-part article shows how simple, modular microprocessor blocks may be built and programmed for control of many ham equipment functions. There are only four basic circuit board blocks: the microprocessor; a simulator for programming; bus status indication; and application cards. These can become the heart of a memory keyer or buffered Morse keyboard, a synthesizer controller, repeater controller, transceiver controller or control for a swept-frequency signal generator. Some of these will be covered in future articles.

The boards are intended to be standard so that no hardware changes are required when changing applications. Since many application boards may be used, a common board interconnection, or HAM BUS, has been developed.

why intelligent control?

Standard, or dedicated, circuit design has its function limited by design. Function changes require hardware modification.

An intelligent controller performs a series of events under programmed control. The program can be written to make choices; it is "intelligent." A microprocessor and its peripheral chips do this digitally. More than one task can be performed and changes require only reprogramming. You don't have to rebuild from scratch.

By C.A. Eubanks, N3CA, P.O. Box 127, Valencia, Pennsylvania 16059

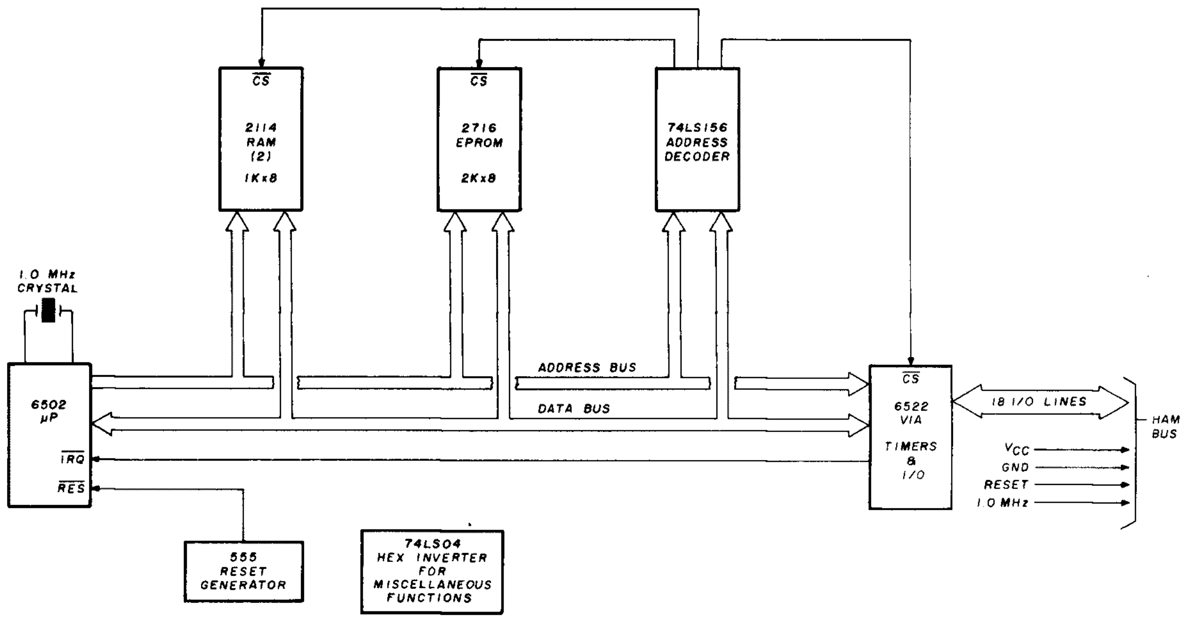

fig. 1. Microprocessor card block diagram. HAM BUS is the interconnect to application cards interfacing with external devices.

With the proper software (program), an intelligent controller could display the time of day, display a transmitter frequency, show the i-f offset, *and* control test equipment. Circuit changes aren't needed.

The greatest benefit of intelligent control is that it's easily possible to go back and change features that didn't work out quite right. It is also possible to add bells and whistles as they come to mind. If this had been tried with dedicated circuitry, the project would never have gotten off the breadboard.

beginning the system concept

The main choice is that of microprocessors and support devices. The wide selection of support devices includes many with varying degrees of internal intelligence. Another choice is the construction and interconnection method. My own choice was to write down a set of objectives (see **table 1**).

table 1. Objectives for the intelligent controller.

1. Use commonly available, low-cost components.
2. Microprocessor type should be compatible with low-cost, available-development systems to support software.
3. Reduce circuit complexity and minimize parts counts.
4. Place controller operation burden on software to minimize hardware cost and parts count.
5. Reduce the number of board interconnects for least circuit loading and RFI, minimum timing problems.
6. Segregate circuit board functions so a minimum are needed for any particular application.

Some objectives are worth detailing. Ease of program development and software/hardware troubleshooting are keys to success. Since I couldn't afford a professional microprocessor development system, an inexpensive way to assemble and test the programs was needed. Program test is crucial; it is virtually mandatory to step through programs one line at a time to ensure proper operation.

Keeping down the parts count as well as the level of complexity has several benefits. The cost in dollars for my time, for experimenting and building, is nil — but I'm willing to pay a few extra dollars if one LSI chip can replace several common devices. This reduces hardware complexity so that there is a better chance of getting the controller system debugged and running.

I wanted to reduce the number of microprocessor address and data busses. Three factors affect the design: First, the system is a controller, *not* a computer. Second, there can be timing and circuit-loading problems with extended bussing. Third, square-edged signals spread harmonics way up the spectrum. I've had microprocessor hash problems before, and I decided that RFI control is easier with fewer signal lines.

Function segregation allows debugging the system

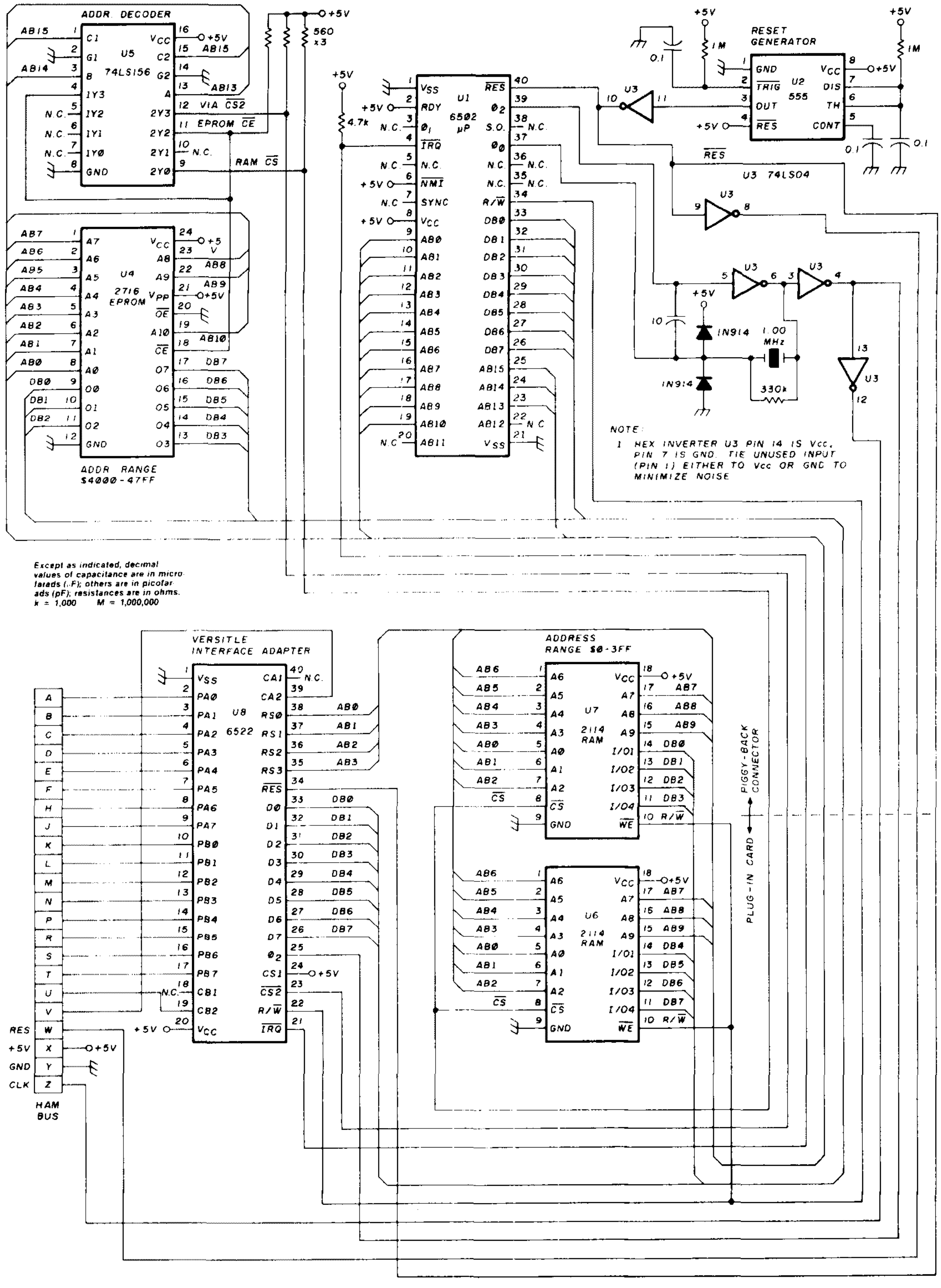

fig. 2. Schematic of microprocessor card. Two boards are used in construction, see text and *fig. 11* for details.

one board at a time. The worst trouble-shooting situation occurs when it's not clear whether the trouble lies in software or hardware; segregation reduces these software/hardware problems. Segregation also permits adding applications as required.

microprocessor selection

I did a lot of searching for the right microprocessor. My final choice was the 6502. This chip is the basis for the KIM, SYM, and AIM single-board computers, as well as for the central processor of the Apple, Commodore, and Atari personal computers. The 6502 instruction set is relatively easy to understand and is easy to interface to both memory and peripherals.

The low price of the KIM, SYM, and AIM systems is also important. These three are similar enough to be used interchangeably with the equipment described here.

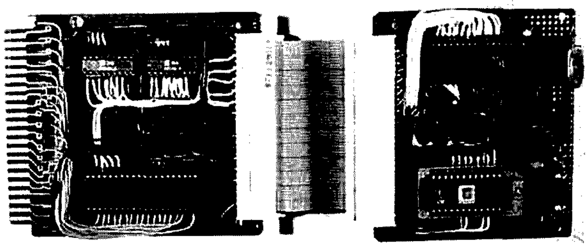

fig. 3. Microprocessor card with boards unfolded.

the microprocessor

Fig. 1 is the microprocessor card block diagram. **Fig. 2** is the schematic diagram. This module has double-board construction (see **fig. 3**). Construction is detailed later.

I decided to use a 1.0-MHz crystal oscillator for the microprocessor clock with the idea that a better, external oscillator could be used later. This later change would apply to a frequency synthesizer having a stable frequency and phase timebase.

Random Access Memory (RAM) for scratch-pad storage is provided by two 2114 static RAM chips. Each is 1K by four bits, a total of 1K by eight bytes of RAM (1024 eight-bit bytes). Programs are stored in a 2716 Erasable Programmable Read Only Memory (EPROM), giving 2K (2048) bytes of program. The 2716 is available in the five to ten dollar range.[1] A 2732 (4K by eight) may be substituted easily for more program space. Each can be erased with ultraviolet light.[2]

Address decoding uses a 74LS156 three-to-eight-line decoder to enable RAM, EPROM, or the 6522 Versatile Interface Adapter (VIA). Decoding breaks memory addressing into eight 8K blocks. This wastes addresses but I didn't expect control programs to run more than a few K.

Some AIM-65 circuit features were borrowed. The

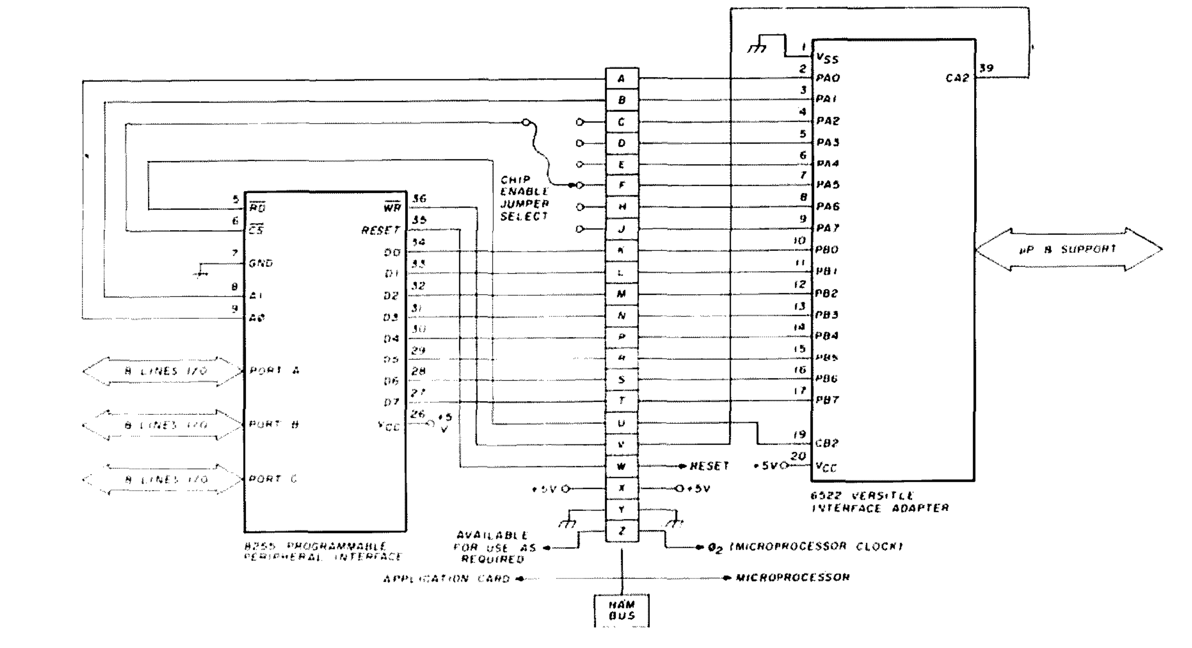

fig. 4. The basic application card. External devices input and output through ports A, B, and C.

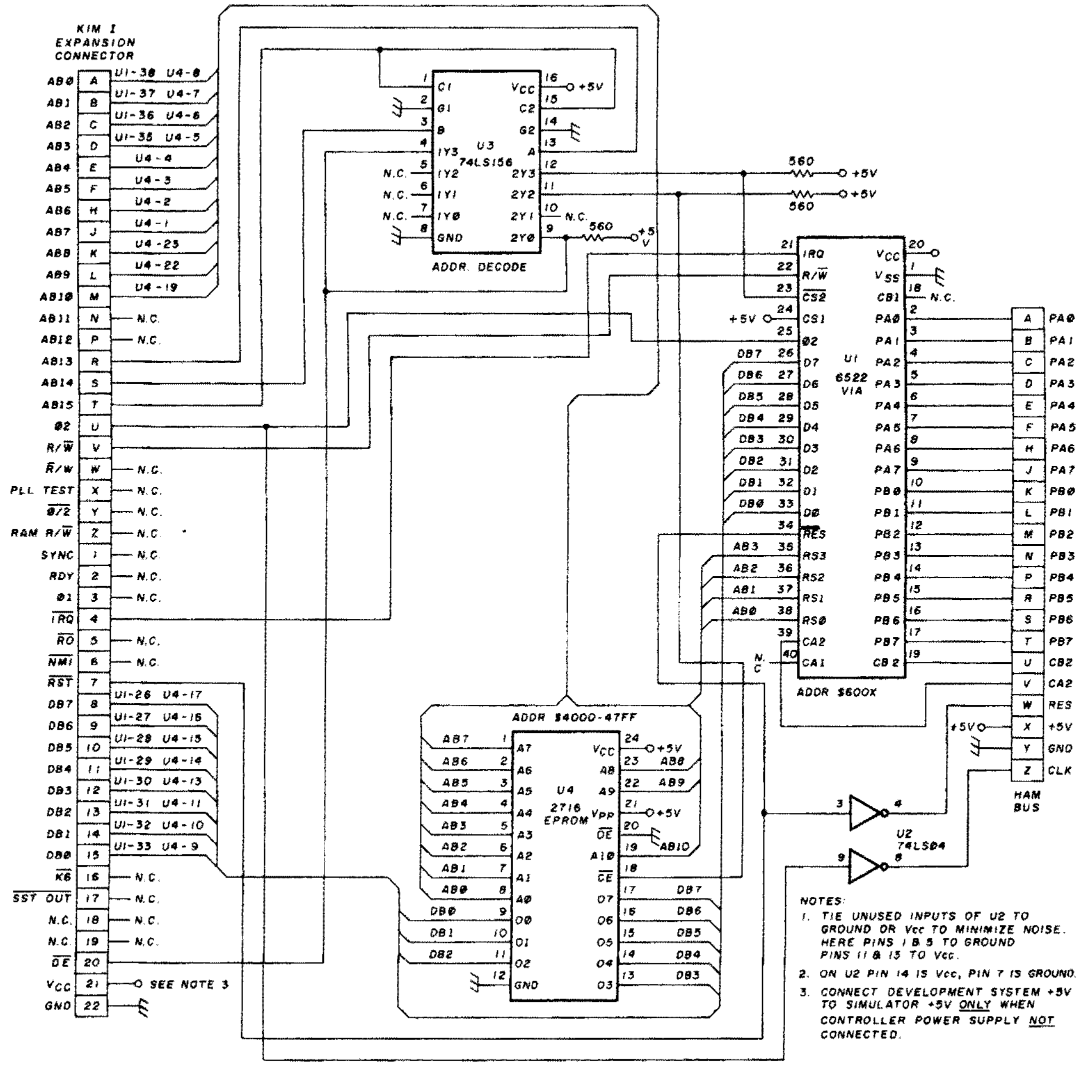

fig. 5. Simulator card schematic for program development on KIM, SYM, or AIM single-board computers.

555 timer is connected as a one-shot to reset the microprocessor on power-up. I chose the 6522 VIA to communicate with all other boards and to provide timing ("heartbeat") to service them. The VIA has twenty programmable I/O (Input/Output) lines (eighteen are used) and two sixteen-bit counters programmable to count down at the microprocessor clock rate. Either counter can provide interrupts (IRQ line) on the time-out, and one counter can interrupt on a repetitive basis. The latter is ideal as a heartbeat device.

cards and interconnection

I selected an available prototype card for board construction with twenty-two or forty-four edge connections at 0.156-inch (3.95-mm) spacing. Edge connection is compatible with expansion ports on the KIM, SYM, or AIM. I wanted to use only twenty-two pins on one side of the card, hoping to get single-side, etched circuit boards later.

Each pin of the connector is common to all boards, and I've called this the HAM BUS. This bus carries +5 Vdc, ground, the microprocessor clock, VIA control lines CA2 and CB2, and the sixteen bi-directional VIA port lines. This isn't enough for interfacing directly to external functions.

the basic application card

Each application card connects the HAM BUS to external equipment. I picked an Intel 8255 Program-

mable Peripheral Interface (PPI) for the basic interface shown in fig. 4. Originally designed for the 8080 microprocessor, it has twenty-four latched, programmable I/O lines controlled by the HAM BUS.

To avoid extra address decoding, I assigned six lines (PA2 to PA7) for jumpered chip selection ($\overline{CS}$, pin 6). This limits the number of application cards to six, but I considered this enough for the original purpose. Six application cards permit eighteen eight-bit external connections or twelve eight-bit and twelve four-bit groups; port C of the PPI can be set to either one eight-bit or two four-bit configurations by the program.

Control of the PPI is covered in Part 2 and it includes an eight-digit display card. Other application cards will be covered in future articles.

simulator card

The microprocessor board runs the program stored in its EPROM, but there is no way to tell what it is doing. The simulator card of **figs. 5** and **6** allows a KIM-1 to be substituted for the microprocessor. The KIM (or SYM or AIM) can step through each instruction in the EPROM to observe program operation.

The simulator card's cable and connector are compatible with either KIM or SYM expansion connectors or J3 on the AIM-65. Connection to pin 20 of J3 on the AIM-65 or pin 20 of the SYM expansion connector must be *open*. Labeling in **fig. 5** assumes a KIM-1 modified as follows: A jumper from the KIM application connector pin K is made to expansion connector pin 20. With no attached simulator cable, either pin K or pin 20 must be grounded so that the KIM can decode internally.

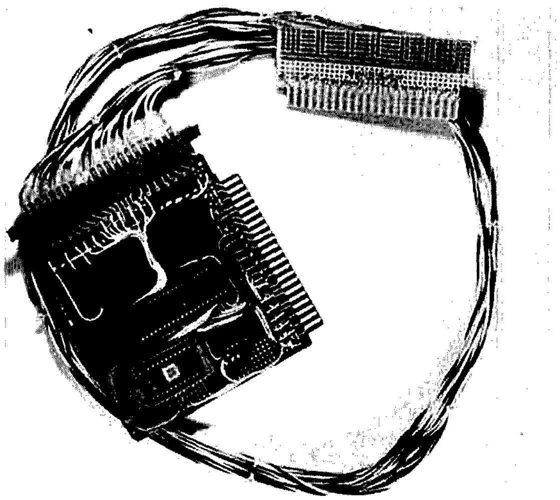

fig. 6. Simulator card with development system cable. Cable connector is edge removed from piggy-back microprocessor card.

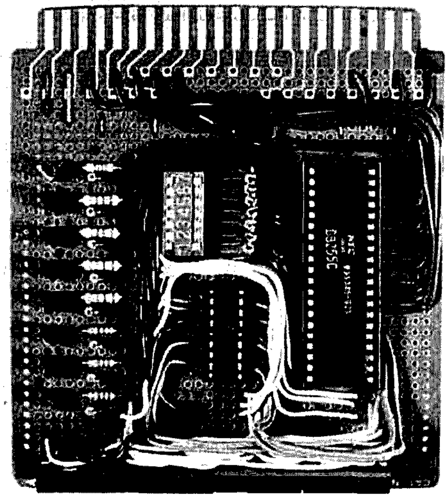

fig. 7. Mother board and KIM-1 development system. Bus status and digit display application cards are installed on mother board; simulator is plugged into KIM expansion connector.

Fig. 7 shows the controller card cage with simulator connected to a KIM-1. Bus status and eight-digit display cards are installed in the controller cage, with microprocessor card removed. The simulator card must be removed, and replaced with the microprocessor card for stand-alone controller operation.

bus status indicator

A helpful diagnostic tool is the status indicator card shown in **figs. 8** and **9**. It is simply a set of LED drivers to show all HAM BUS logic states.

The bus status indicator will work with either microprocessor or simulator cards. It is useful in checking both hardware and software, since the HAM BUS is between the external device and microprocessor.

Testing is aided by ordering the LEDs in the same location as the HAM BUS lines and including line marking labels. I used a piece of thin plastic for marking, cementing it to the LEDs and board with silicone rubber sealant.

mother board

This is the last item; see **fig. 10**. The mother board is double-sided PCB stock (mine was obtained at a hamfest) with edge connectors for all cards. Each alphabetic pin is common on all connectors, so that any card will fit any connector. The simulator card should be inserted close to the development system to minimize lead length.

I used wire-wrap sockets for edge connectors (Radio Shack P/N 276-1550) with wrap pins soldered to etched HAM BUS lines. Wire-wrap pins allow easy connection for future expansion.

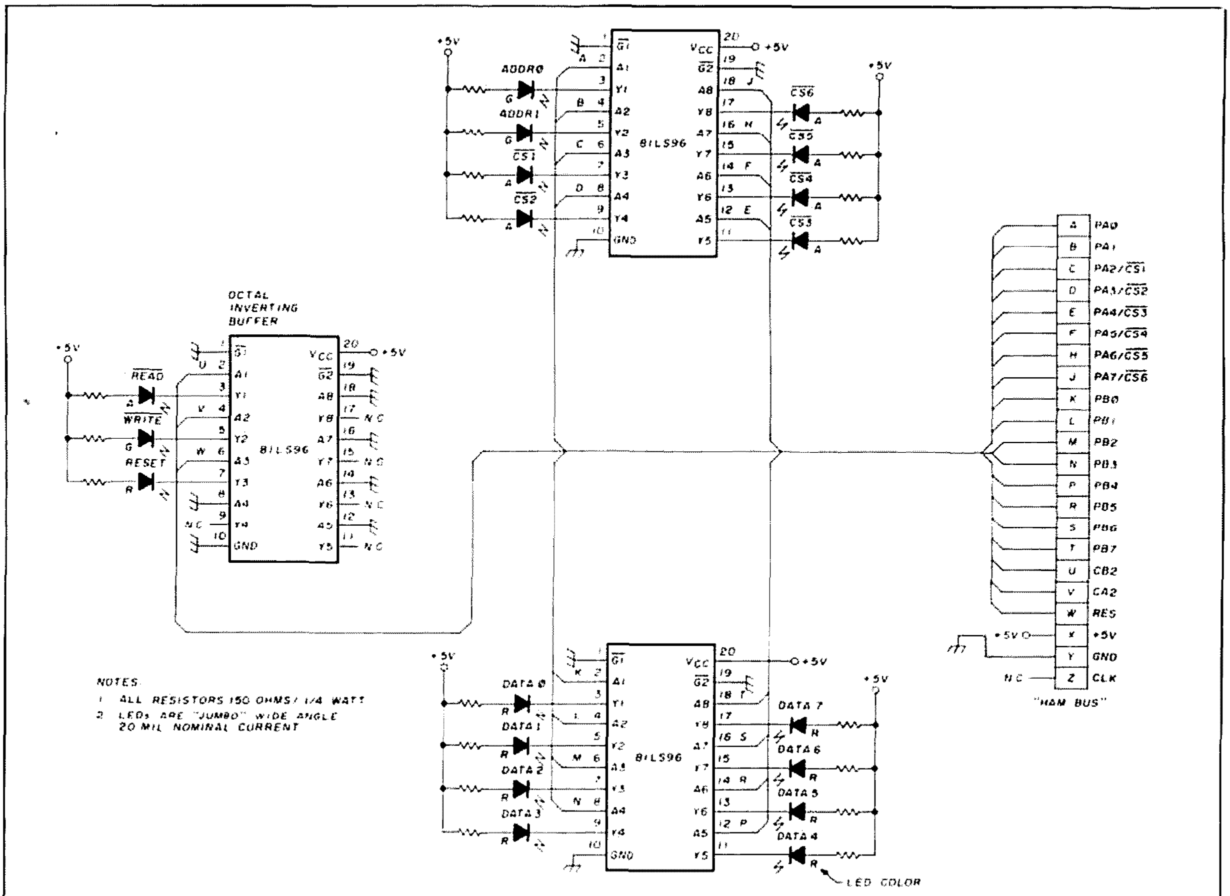

fig. 8. Bus status indicator card schematic.

Unetched foil on both sides serves as a ground plane. Ground areas on both sides should have shorting wires every few inches. Ultimately, the mother board ground plane should be connected to a metal enclosure for minimum RFI.

construction notes

I used sockets for all ICs with short-length soldered wires. Sockets save a lot of headaches (and ICs) in the event of problems. A Zero Insertion Force (ZIF) socket was used for the EPROM to ease program changes. A ZIF is larger than normal, so some care must be taken in location and wire dress.

Exact component location on cards is not important, except that wiring should be short. **Fig. 11** indicates the piggy-back construction of the microprocessor. The removed edge connection of one board becomes the second connector for the simulator. For an "open" development system board (KIM, SYM), the simulator card is inserted in the development sys-

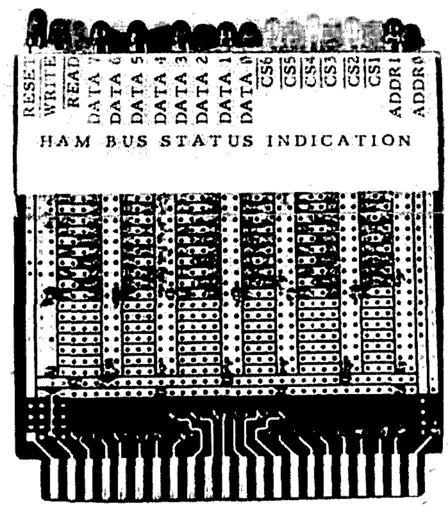

fig. 9. Bus status indicator card showing LED marking plate.

tem with cable and leftover connector edge to the mother board. Use of an AIM-65 with cover requires reversing card and cable locations.

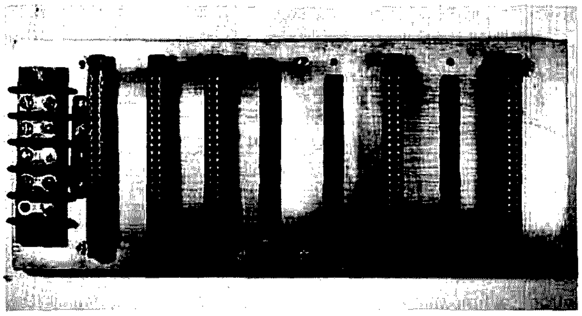

fig. 10. Top side of mother board. Terminals connect to controller power supply.

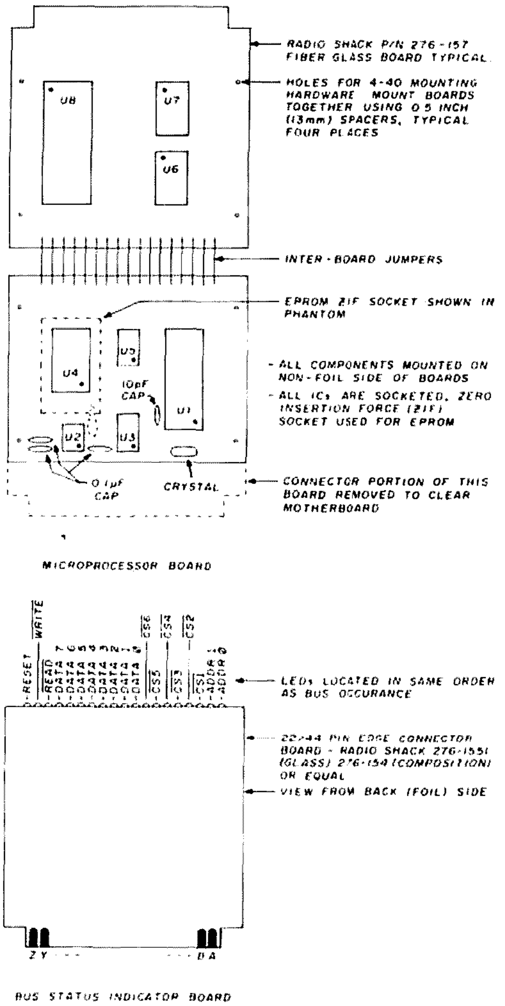

fig. 11. Circuit card construction and layout.

I suggest the following construction sequence: Simulator; mother board and bus status indicator; an application card; then the microprocessor. This gives you a break from hardware work for programming and testing.

The following extra tools and materials are suggested:

1. Fingernail clippers with a notch filed on one cutter edge, for stripping and close trimming.
2. An assortment of dental probes, reground to suit. See your dentist for thrown-away tools.
3. A *small* pencil-type iron with cleaning sponge.
4. *Solder Wick* for removing excess solder.
5. An IC extraction tool, 24-pin maximum size. I found that a little stretching would make it fit larger ICs.
6. Red fingernail polish for marking parts.

I found it handy to mark pin 1 of both ICs and sockets, including cards and their connectors. Dental probes can be used to ream holes in development boards. Solid wire with colored insulation is helpful; I used multi-conductor 22 AWG, available in 25-foot lengths, separating as needed.

Number and spacing of connectors on the mother board is optional. Edge connectors can be added as the system grows.

coming up next

The second half of this article will give details on the VIA-PPI control method and also present some general program flow diagrams. An eight-digit numeric display applications board is included. Send the author a self-addressed, stamped envelope for information on program documentation and burned EPROMs.

references

1. C.A. Eubanks, N3CA, "2716 EPROM Programmer, *ham radio*, April, 1982, pages 32-36.
2. L.B. Golter, "Build a Low-Cost EPROM Eraser," *Byte*, April, 1980, pages 234-238. A commercial version of this unit is available for $39.95 from Jade Computer products, 4901 West Rosecrans Avenue, Hawthorne, California 90250; Catalog number XME-3200.

bibliography

A large number of microprocessor tutorials and texts are available from computer stores. One softcover book covers both the 6502 and 6522, including some instruction examples: *6502 Assembly Language Programming*, Lance A. Leventhal, 1979, Osborne/McGraw-Hill.

Timing of the 6522 is covered well in the *Synertek 1981-1982 Data Catalog*, pages 3-95 to 3-144. It is available from Synertek, P.O. Box 552, MS/34, Santa Clara, California 95022. Details on the Intel 8255 can be found in their *1981 Peripheral Design Handbook*, pages 1-333 to 1-353. It is available from Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

The ground plane antenna was well-known as an antenna for VHF work during the early Forties, but not until about 1948 was it used for long-distance, high-frequency communications — and with much success, I might add. Even so, some hams scorn the simple ground plane antenna as being "equally weak in all directions."

The question of the relative merits of the dipole and the ground plane has floated around in limbo for some years. I have used both of them, but never at the same time. During the past year, however, I had an unparalleled opportunity to use a representative high-frequency ground plane and horizontal dipole concurrently under unusual conditions. The experience led me to make some interesting conclusions about both types of antennas. The question I asked myself and tried to answer was, "Which antenna is the best for all-round high-frequency DX operation, the dipole or the ground plane?"

testing the two antennas

The testing ground was the newly proposed 10-MHz Amateur band. In early 1980, I erected a dipole for this band, followed soon afterward by the ground plane. The physical installa-

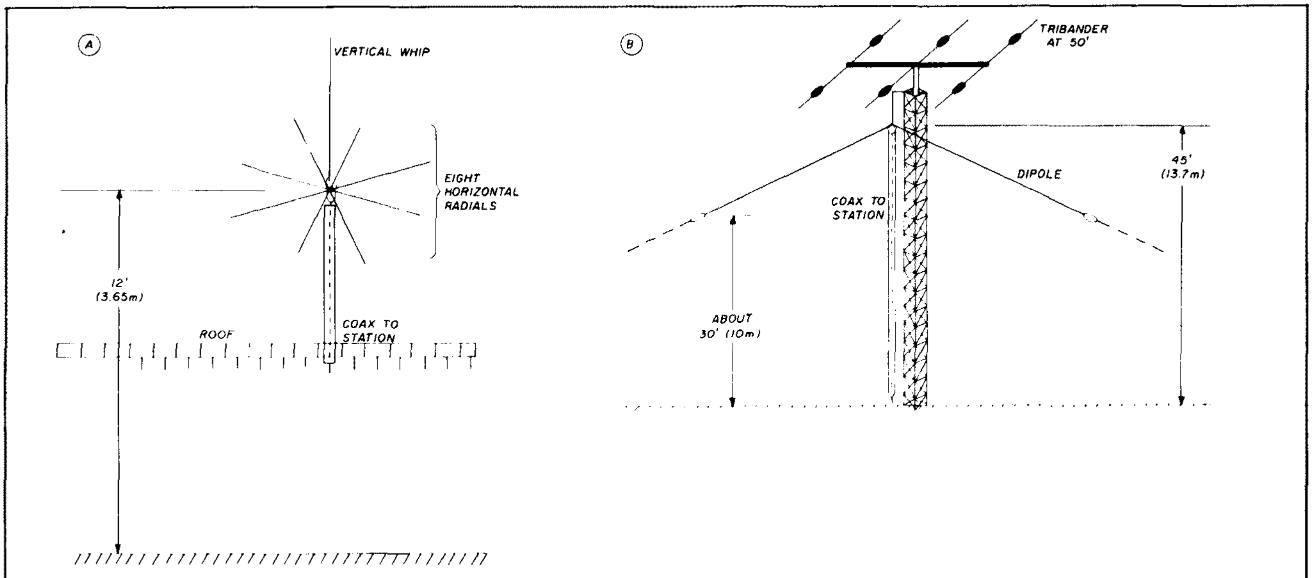

fig. 1. Comparison of a good ground plane antenna and a dipole at 10 MHz. (A) The ground plane was roof-mounted with eight radials in a near-horizontal plane. (B) The dipole was slung from a short arm on the tower 45 feet up.

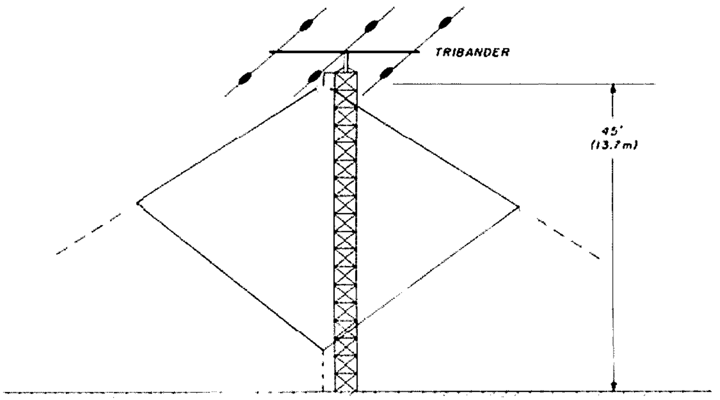

fig. 2. The dipole was converted into a quad loop, a quarter-wave on a leg. Loop was fed at the top with a coaxial line. No apparent differences in signal strength could be observed.

tion I used is detailed in fig. 1. Both antennas were well in the clear in all directions except to the west, where there was a slight rise in the ground level about 300 feet from the antennas. To the east there was an excellent shot down a slight grade to San Francisco Bay, about four miles away.

I was familiar with my location's idiosyncracies on both 7 MHz and 14 MHz, and I felt that leisurely observing DX signals over a period of time on the 10-MHz band (where no ham signals existed in 1980 and 1981) would be interesting. A large enough number of identifiable signals were logged among the many commercial and broadcast stations that could be heard that a good receiving check of the two antennas was possible.

January 1, 1982 — the band opens up

At the stroke of the new year, Amateur signals appeared on 10 MHz, but, alas, none from the United States (those that worked hardest to get the band will probably be the last ones on — an ironic tribute to U.S. Amateurs). A good spread of Amateur signals around the globe, coupled with a little QRM, provided an excellent test for the antennas, which could be selected at the flick of a coaxial switch. Some of the most interesting reception tests were run on VK9YC on the Cocos-Keeling Islands in the Indian Ocean, who showed up like clockwork for a short time around 0000Z, the long path over Africa. On the same skip, VK6AKG in western Australia could often be heard. European signals coming through the short path were also good checks, as were ham signals from Mexico and Central and South America.

By mid-year, 1982, I had listened to enough signals from all distances to draw some tentative conclusions as to performance of the two antennas. Here are some of the conclusions i came to:

1. The vertical ground plane antenna is vastly more sensitive to manmade noise than is the horizontal dipole. Noise rejection of the dipole over the ground plane was as high as 30 dB in some cases. If you are troubled with power line, ignition, or other manmade noises, the vertical antenna is not for you.

2. The horizontal dipole is more susceptible to atmospheric noise (background hiss, static, etc.) than the vertical. If no manmade noise is present, the vertical antenna is quieter than the horizontal.

3. On signal reception from stations as close as WWV in Colorado to

VK9YC, in no instance was the ground plane vertical better than the dipole. Usually it was one-half to one S-unit weaker than the horizontal antenna. Over the long pull, even if signals appeared to be of equal strength on the two antennas, the signal on the horizontal dipole was *more readable over a period of time* than was the signal received on the vertical ground plane.

what this means

It was an interesting comparison. The vertical antenna had eight nearly-horizontal radials beneath it and it was high enough in the air so as to be clear of telephone wires and nearby objects. It was a good ground plane in a good, typical location. The dipole was suspended in the clear from my tower, with the ends drooping slightly, since they were tied to nearby handy objects. The base of the ground plane was about 12 feet (3.65 meters) above the ground and the center of the dipole was about 45 feet (13.7 meters) above the ground. Thus, the ground plane base was just about 0.13 wavelength above ground and the dipole center was about 0.5 wavelength above ground — typical dimensions for Amateur installations.

According to vertical angle radiation plots beloved by Amateur antenna specialists, the ground plane should be putting out most of its energy very close to the horizon, at perhaps ten to twelve degrees of elevation. On the other hand, the dipole should have its maximum lobe of radiation at an angle of about thirty degrees above the horizon. The dipole should be good for short distances and the ground plane good for long-distance DX.

Alas, no such clean line of demarcation can be made. In real life, the earth is a lumpy reflector of questionable conductivity, spotted with utility wires, streets, houses, and other large objects in the vicinity of the ham antenna. Scientific measurements often come unglued in suburbia.

If I had to make a choice, I'd opt for the horizontal dipole because it *is* less noisy and provides a better signal-to-noise ratio than the ground plane most of the time. Yes, I know many famous DXers use a ground plane with great results, but have they ever directly compared the ground plane against the vertical in a real situation?

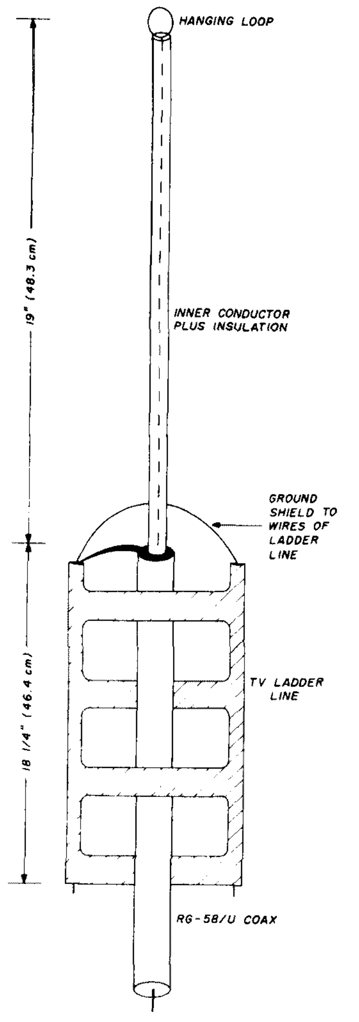

fig. 3. The KA4OFE answer to the 2-meter rubber duckie antenna. Costing just pennies, this simple dipole runs rings around an HT antenna. It can be rolled up and stuffed in your pocket (depending upon the length of the feedline). It's a great antenna for an emergency when you need the punch to break into a distant repeater!

I doubt it. I'll take the extra dB or so of signal-to-noise ratio I gain with the dipole and out-hear you every time.

the dipole versus the single quad loop

The final experiment was a comparison of the dipole with a single quad loop whose apex was at the same height as the center of the dipole (**fig. 2**). Unfortunately, these antennas could not be concurrently compared. One had to be taken down so the other could be erected; the only comparisons, therefore, were on a day-to-day basis. Since the 10-MHz band (like other bands) changes from day to day, the results of this investigation are open to interpretation.

After a week or so of pulling antennas up and down and listening to DX signals, I concluded that there isn't any difference worth mentioning between the two. I couldn't determine if the small gain (reputed to be about 1.2 dB) of the loop over the dipole was worth the complexity of the installation. After a few weeks, the loop was dismantled and I reached a final conclusion: it is pretty difficult to devise a better antenna than a simple dipole, mounted at least a half-wavelength in the air. If any of my readers come up with a simple antenna (the key word is *simple*) that outplays the dipole, I'd be pleased to hear about it!

a cheap and easy gain antenna for 2 meters

Do you want extended range for your 2-meter HT? Many of us have found that the rubber duckie antenna doesn't do a very good job at any distance from a repeater. Here's an inexpensive antenna that will boost your operating range many times over that of the duck.

As far as I know, this antenna was designed by Woody, KA4OFE. I received the instructions from him and immediately tried it out on some distant repeaters. Wow! It opened up a whole new world of HT communications.

This simple antenna is shown in

fig. 3. It is simply a vertical dipole with the lower half made of a section of 450-ohm TV ladder line.

The top section of the dipole is made from the center conductor of the coaxial line, with the white dielectric material left in place. A hang-up loop is formed at the top and the distance from the top of the loop to the *braid is 19 inches (45 cm). Enough* braid is left to form a pigtail, which is soldered to a crossover wire between the two wires of the ladder line.

The 50-ohm coax should be woven in and out through the lattices of the ladder line, keeping it centered as much as possible. The coax could then be tied in position along the ladder line by monofilament fishing line, if you desire.

The two wires of the line are separated at the bottom end and joined at the top end, at which point the coax braid is attached. The ladder line seems to work well as a decoupling stub, and when the antenna is mounted in the clear (hung from a branch of a tree, for example) it is a great improvement over a conventional HT antenna — even a full-size one. SWR on the line is low and so far I have encountered no loading problems with any equipment.

My model of the KA4OFE antenna comes complete with a 25-foot (7.62 meter) lead-in and a matching plug to fit the HT on the free end of the line. The antenna can be coiled up into a small bundle and erected in a few minutes time. It's a lot of antenna for very little money!

last call for EME notes

Some time ago I offered readers of this column a brochure entitled *All You Want to Know About Moonbounce*, a series of reprints of interesting EME (earth-moon-earth) information. I now have more reprints and if you send me four first-class stamps or four IRCs, I'll be pleased to send the material to you. Send your request to me at EIMAC, 301 Industrial Way, San Carlos, California 94070.

ham radio

computer-aided UHF preamplifier design

A review of transistorized preamplifier considerations, plus a computer program to speed up the design procedure

How often have you wished you could find a way to use one of those bargain transistors in a preamplifier or receiver front-end project? Or, looking through the data books, how many times have you wanted a quick way to determine whether a device would work for your application before you bought it? If you have access to a computer, this program will take the data-book S-parameters of a transistor and not only tell you if it is usable, but also will design the amplifier input and output matching networks. To better understand what the computer will do for you, let's take a look at some important requirements in transistor design.

stability

Many Amateurs shy away from building preamplifiers for low-noise applications because too many times those amplifiers turn into oscillators. However, with proper construction techniques and a stable theoretical design, a preamplifier could be a simple weekend project.

The stability of a device depends not only on the device itself but also on the load and source terminations provided by the matching networks. An active device is unconditionally stable if no combination of load and source impedances will cause the circuit to oscillate. A way to mathematically determine the potential stability of a device is by evaluating the stability factor, K:

$$K = \frac{1 + |\Delta|^2 - |S_{11}|^2 - |S_{22}|^2}{2 \bullet |S_{21} \bullet S_{12}|} \qquad (1)$$

where:
S_{11} = *input reflection coefficient*
S_{12} = *reverse transmission coefficient*
S_{21} = *forward transmission coefficient*
S_{22} = *output reflection coefficient*
$\Delta = S_{11} \bullet S_{22} - S_{12} \bullet S_{21}$

If $K > +1$, the device is unconditionally stable, if $K < 1$, the device is potentially unstable. Do not automatically discard a device if K is less than one, because all that has been determined is that there are passive terminations which *could* cause the stage to oscillate. There are ways around this problem. For in-

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stance, changing V_{CE}, I_C, or both in a bipolar transistor will change the S-parameters of the device, and conditions could be found that will make $K > +1$. This approach is generally not preferred because the bias point of a transistor is also determined by other requirements, such as dc power consumption and noise figure, but could be considered as an alternative solution for some conditions.

A second alternative could be selective mismatching. This approach stabilizes the device by mismatching the output of the transistor, causing the gain to be reduced. It also requires the use of constant-gain circles on a Smith chart to determine both the gain and the load termination for the device.

A third approach is to add a resistor, either in series or in parallel with the input or output. However, for small-signal amplifiers, resistive loading on the input introduces losses that will degrade the noise figure of the amplifier. (In power amplifiers, resistive loading on the output is avoided because of the associated power losses.) The computer program (**fig. 1**) has been written for selective mismatching or resistive shunt loading on the device output.

for K > +1

It is a simple task to design an amplifier when K is greater than +1. Compute the reflection coefficient of the source impedance that provides a conjugate match to the input of the transistor (**eq. 2**), and the reflection coefficient of the load impedance that provides a conjugate match to the output of the transistor (**eq. 3**). The following equations compute those reflection coefficients:

$$\Gamma MS = C_1^* \bullet \left[\frac{B_1 \pm \sqrt{B_1^2 - 4 \bullet |C_1|^2}}{2 \bullet |C_1|^2} \right] \quad (2)$$

where: ΓMS = *reflection coefficient of the source impedance*

$B_1 = 1 + |S_{11}|^2 - |S_{22}|^2 - |\Delta|^2$

$C_1 = S_{11} - \Delta \bullet S_{22}^*$

$$\Gamma ML = C_2^* \bullet \left[\frac{B_2 \pm \sqrt{B_2^2 - 4 \bullet |C_2|^2}}{2 \bullet |C_2|^2} \right] \quad (3)$$

where: ΓML = reflection coefficient of the load impedance

$B_2 = 1 + |S_{22}|^2 - |S_{11}|^2 - |\Delta|^2$

$C_2 = S_{22} - \Delta \bullet S_{11}^*$

If $B_1 < 0$, then the plus sign should be used in front of the square root in **eq. 2**, or the minus sign if $B_1 \geq 0$. The same is true in **eq. 3** for B_2.

The maximum power gain, G_{MAX}, is determined from **eq. 4**:

*Super-Compact is a trademark of Compact Engineering, Inc.

$$G_{MAX}\ (DB) = 10 \bullet LOG \left[\frac{|S_{21}|}{|S_{12}|} \left| K \pm \sqrt{K^2 - 1} \right| \right] \quad (4)$$

If B_1, from **eq. 2**, is negative, the plus sign precedes the square root, or the minus sign precedes the square root if B_1 is positive.

constant-gain circles

Constant-gain circles are useful in cases where a

fig. 1. Computer program listing.

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10 ' THIS PROGRAM DESIGNS AMPLIFIERS USING 'S-PARAMETERS'
20 ' WRITTEN BY G.WATT-16MARCH1982
30 CLS
40 PRINT:PRINT" THIS PROGRAM DESIGNS SMALL     SIGNAL AMPLIFIERS USING S-     PARAMETERS."
50 RAD=57.29577951:PI=3.1415926
60 PRINT:INPUT" S11(M,P)=";WM,WP:WP=WP/RAD
70 PRINT:INPUT" S12(M,P)=";XM,XP:XP=XP/RAD
80 PRINT:INPUT" S21(M,P)=";YM,YP:YP=YP/RAD
90 PRINT:INPUT" S22(M,P)=";ZM,ZP:ZP=ZP/RAD
100 S1=WM:S2=WP:S3=XM:S4=XP:S5=YM:S6=YP:S7=ZM:S8=ZP
110 GOSUB 890
120 GOSUB 970
130 GOSUB 1030
140 IF K<1 GOTO 490
150 GOSUB 1070
160 GOSUB 1090
170 GOSUB 1110
180 TL=(B2+(B4*SQR((B2^2)-(4*(CM^2)))))/(2*CM)
190 TCP=-CP*RAD
200 GOSUB 1180
210 TS=(B1+(B3*SQR((B1^2)-(4*(EM^2)))))/(2*EM)
220 TEP=-EP*RAD
230 CLS
240 PRINT:PRINT" MAG="(INT(MAG*100)/100)"DB   MSG="(INT(MSG*100)/100)"DB"
250 PRINT:PRINT" GAMMA MS="(INT(TS*1000)/1000)","(INT(TEP*100)/100)
260 PRINT:PRINT" GAMMA ML="(INT(TL*1000)/1000)","(INT(TCP*100)/100)
270 PRINT:PRINT" K="(INT(K*1000)/1000)" "S$
280 PRINT:INPUT" DO YOU WANT TO DESIGN FOR A    SPECIFIC GAIN, INPUT/OUTPUT    MATCHING NETWORK, OR QU
IT -    (G,M,Q)";Q$
290 IF Q$="Q" GOTO 860
300 IF Q$="G" GOTO 420
310 CLS:PRINT:INPUT" THE INPUT/OUTPUT NETWORKS WILL  BE DESIGNED USING TWO ELEMENTS, SERIES CAPACITO
RS AND SHUNT    INDUCTORS.                WHAT IS THE TERMINATING VALUE   OF RESISTANCE FOR THE NETWORK
S  (OHMS)";Z0
320 Y0=1/Z0
330 PRINT:INPUT" WHAT IS THE CENTER FREQUENCY OF THE AMPLIFIER (MHZ)";FR:FR=FR*1E+06
340 GOSUB 1990
350 CLS:PRINT:PRINT"        INPUT NETWORK";
360 PRINT:PRINT" SERIES CAP.="(INT(U7*1E+14)/100)"PF"
370 PRINT" SHUNT IND.="(INT(U8*1E+11)/100)"NH"
380 PRINT:PRINT"        OUTPUT NETWORK";
390 PRINT:PRINT" SERIES CAP.="(INT(U3*1E+14)/100)"PF"
400 PRINT" SHUNT IND.="(INT(U4*1E+11)/100)"NH"
410 GOTO 860
420 PRINT:INPUT" AMPLIFIER GAIN(DB)";GP
430 GOSUB 1250
440 GOSUB 1360
450 CLS
460 PRINT:PRINT" CENTER OF CONSTANT GAIN CIRCLE  ON OUTPUT="(INT(GM*1000)/1000)","(INT(-CP*RAD*100)/100)
470 PRINT:PRINT" RADIUS OF CONSTANT GAIN CIRCLE  ON OUTPUT="(INT(PG*1000)/1000)
480 GOTO 720
490 GOSUB 1110
500 GOSUB 1250
510 GOSUB 1290
520 GOSUB 1180
530 GOSUB 1390
540 GOSUB 1410
550 GOSUB 2270
560 CLS
570 PRINT:PRINT" CENTER OF STABILITY CIRCLE ON   INPUT (M,P)="(INT(HM*1000)/1000)","(INT(-EQ*RAD*100)/100)
580 PRINT" RADIUS OF STABILITY CIRCLE ON   INPUT="(INT(P1*1000)/1000)"   "D$
590 PRINT:PRINT" CENTER OF STABILITY CIRCLE ON   OUTPUT (M,P)="(INT(FM*1000)/1000)","(INT(-CQ*RAD*100)/100)
600 PRINT" RADIUS OF STABILITY CIRCLE ON   OUTPUT="(INT(R2*1000)/1000)"   "E$
610 GOSUB 1070
620 PRINT:PRINT" K="(INT(K*1000)/1000)""S$"   MSG="(INT(MSG*100)/100)"DB"
630 PRINT:INPUT" DO YOU WANT GAIN CIRCLE, SHUNT  RESISTOR OR QUIT (G,R,Q)";A$
640 IF A$="Q" GOTO 860
650 IF A$="R" GOTO 790
660 IF A$="G" GOTO 680
670 GOTO 630
680 CLS:PRINT:INPUT" INPUT GAIN (DB)";GP
690 GOSUB 1250:GOSUB 1360
700 PRINT:PRINT" CONSTANT GAIN CIRCLE FOR"GP"   DB (M,P)="(INT(GM*1000)/1000)","(INT(-CP*RAD*100)/100)
710 PRINT:PRINT" RADIUS OF CONSTANT GAIN CIRCLE  ="(INT(PG*1000)/1000)
720 PRINT:INPUT" INPUT REFLECTION COEFFICIENT    OF LOAD CHOSEN FROM THE SMITH   CHART (M,P)";OM,OP:OP=O
P/RAD
730 GOSUB 1480
740 PRINT:PRINT" SOURCE REFLECTION COEFFICIENT   FOR THE LOAD IS"(INT(MM*1000)/1000)","(INT(MP*RAD*100)/1
00)
750 PRINT:INPUT" DO YOU WANT TO DESIGN MATCHING  NETWORKS OR QUIT (M,Q)";K$
760 IF K$="Q" GOTO 860
770 TL=OM:CP=OP:TS=MM:EP=MP
780 GOTO 310
790 CLS:PRINT:PRINT" THE PROGRAM WILL CALCULATE NEW  S-PARAMETERS FOR THE TRANSISTOR AND A SHUNT RE
SISTOR ON THE    OUTPUT"
800 PRINT:INPUT" ENTER VALUE FOR RESISTOR";RE:CLS
810 WM=S1:WP=S2:XM=S3:XP=S4:YM=S5:YP=S6:ZM=S7:ZP=S8
820 GOSUB 1610
830 GOSUB 1940
840 GOSUB 1610
850 CLS:GOTO 110
860 PRINT:INPUT" RUN PROGRAM OR QUIT(R,Q)";Z$
870 IF Z$="R" GOTO 30
880 CLS:END
890 T1=WM*ZM:T2=WP+ZP
900 T3=XM*YM:T4=XP+YP
910 T5=T1*COS(T2):T6=T1*SIN(T2)
920 T7=T3*COS(T4):T8=T3*SIN(T4)
930 DR=T5-T7:DI=T6-T8
940 DM=SQR((DR*DR)+(DI*DI))
950 DP=2*ATN(DI/(DM+DR))
960 RETURN
970 B1=1+(WM*WM)-(ZM*ZM)-(DM*DM)
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listing continues

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980 B2=1+(ZM*ZM)-(WM*WM)-(DM*DM)
990 IF B1<=0 THEN B3=-1 ELSE B3=1
1000 IF B2<=0 THEN B4=-1 ELSE B4=1
1010 IF B1>=0 THEN S$="+" ELSE S$="-"
1020 RETURN
1030 N=1+(DM*DM)-(WM*WM)-(ZM*ZM)
1040 D=2*YM*XM
1050 K=N/D
1060 RETURN
1070 MSG=10*LOG(YM/XM)/LOG(10)
1080 RETURN
1090 MAG=MSG+10*LOG(ABS(K+B4*SQR((K*K)-1)))/LOG(10)
1100 RETURN
1110 T1=DM*WM:T2=DP-WP
1120 T3=T1*COS(T2):T4=T1*SIN(T2)
1130 T5=ZM*COS(ZP):T6=ZM*SIN(ZP)
1140 CR=T5-T3:CI=T6-T4
1150 CM=SQR((CR*CR)+(CI*CI))
1160 CP=2*ATN(CI/(CM+CR))
1170 RETURN
1180 T1=DM*ZM:T2=DP-ZP
1190 T3=T1*COS(T2):T4=T1*SIN(T2)
1200 T5=WM*COS(WP):T6=WM*SIN(WP)
1210 ER=T5-T3:EI=T6-T4
1220 EM=SQR((ER*ER)+(EI*EI))
1230 EP=2*ATN(EI/(EM+ER))
1240 RETURN
1250 D2=(ZM^2)-(DM^2)
1260 G0=YM^2
1270 G=(10^(0.1*GP))/G0
1280 RETURN
1290 FM=CM/D2
1300 CO=CP
1310 IF FM>=0 GOTO 1340
1320 FM=ABS(FM)
1330 IF CO>=0 THEN CO=CO-PI ELSE CO=CO+PI
1340 R2=ABS(XM*YM/D2)
1350 RETURN
1360 GM=(CM*G)/(1+D2*G)
1370 RG=SQR(1-(2*K*XM*YM*G)+((XM*YM)^2*G*G))/(1+D2*G)
1380 RETURN
1390 D1=(WM^2)-(DM^2)
1400 RETURN
1410 HM=EM/D1
1420 EO=EP
1430 IF HM>=0 GOTO 1460
1440 HM=ABS(HM)
1450 IF EO>=0 THEN EO=EO-PI ELSE EO=EO+PI
1460 R1=ABS(XM*YM/D1)
1470 RETURN
1480 T1=OM*DM:T2=OP+DP
1490 T3=(WM*COS(WP))-(T1*COS(T2))
1500 T4=(WM*SIN(WP))-(T1*SIN(T2))
1510 T5=SQR((T3^2)+(T4^2))
1520 T6=ATN(T4/T3)
1530 IF T3>=0 GOTO 1550
1540 IF T4>=0 THEN T6=T6+PI ELSE T6=T6-PI
1550 T7=OM*ZM:T8=OP+ZP
1560 T9=1-(T7*COS(T8)):U9=-(T7*SIN(T8))
1570 U1=SQR((T9^2)+(U9^2))
1580 U2=2*ATN(U9/(U1+T9))
1590 MM=T5/U1:MP=U2-T6
1600 RETURN
1610 T1=1+WM*COS(WP):T2=WM*SIN(WP)
1620 T3=SQR(T1^2+T2^2):T4=2*ATN(T2/(T3+T1))
1630 T1=1+ZM*COS(ZP):T2=ZM*SIN(ZP)
1640 T5=SQR(T1^2+T2^2):T6=2*ATN(T2/(T5+T1))
1650 T1=T5*T3:T2=T6+T4
1660 T8=XM*YM:T9=XP+YP
1670 T3=T1*COS(T2)-T8*COS(T9)
1680 T4=T1*SIN(T2)-T8*SIN(T9)
1690 U1=SQR(T3^2+T4^2):U2=2*ATN(T4/(U1+T3))
1700 T1=1+ZM*COS(ZP):T2=ZM*SIN(ZP)
1710 T3=SQR(T1^2+T2^2):T4=2*ATN(T2/(T3+T1))
1720 T1=1-WM*COS(WP):T2=-WM*SIN(WP)
1730 T5=SQR(T1^2+T2^2):T6=2*ATN(T2/(T5+T1))
1740 T1=T5*T3:T2=T6+T4
1750 T8=XM*YM:T9=XP+YP
1760 T3=T8*COS(T9)+T1*COS(T2)
1770 T4=T8*SIN(T9)+T1*SIN(T2)
1780 U3=SQR(T3^2+T4^2):U4=2*ATN(T4/(U3+T3))
1790 U5=-2*XM:U6=-2*YM
1800 T1=1+WM*COS(WP):T2=WM*SIN(WP)
1810 T3=SQR(T1^2+T2^2):T4=2*ATN(T2/(T3+T1))
1820 T1=1-ZM*COS(ZP):T2=-ZM*SIN(ZP)
1830 T5=SQR(T1^2+T2^2):T6=2*ATN(T2/(T5+T1))
1840 T1=T5*T3:T2=T6+T4
1850 T8=XM*YM:T9=XP+YP
1860 T3=T8*COS(T9)+T1*COS(T2)
1870 T4=T8*SIN(T9)+T1*SIN(T2)
1880 U7=SQR(T3^2+T4^2):U8=2*ATN(T4/(U7+T3))
1890 WM=U3/U1:WP=U4-U2
1900 XM=U5/U1:XP=XP-U2
1910 YM=U6/U1:YP=YP-U2
1920 ZM=U7/U1:ZP=U8-U2
1930 RETURN
1940 T1=ZM*COS(ZP):T2=ZM*SIN(ZP)
1950 T3=SQ*RE:T4=T1+T3
1960 ZM=SQR(T4^2+T2^2)
1970 ZP=2*ATN(T2/(ZM+T4))
1980 RETURN
1990 T1=-CP:T2=-EP
2000 IF T1>=0 THEN T1=T1-PI ELSE T1=T1+PI
2010 T3=1+TL*COS(T1):T4=TL*SIN(T1)
2020 T5=SQR(T3^2+T4^2)
2030 T6=2*ATN(T4/(T5+T3))
2040 T3=1-TL*COS(T1):T4=-TL*SIN(T1)
2050 T7=SQR(T3^2+T4^2)
2060 T8=2*ATN(T4/(T7+T3))
2070 T3=T5/T7:T4=T6-T8
2080 U1=1/(Y0*T3*COS(T4)):U2=1/(Y0*T3*SIN(T4))
2090 T3=SQR((U1-Z0)*Z0):U3=1/(2*PI*FR*T3)
2100 T4=(Z0^2+T3^2)/T3
2110 T5=1/(2*PI*FR*T4)+1/(2*PI*FR*ABS(U2))
2120 U4=1/((2*PI*FR)^2*T5)
2130 IF T2>=0 THEN T2=T2-PI ELSE T2=T2+PI
2140 T3=1+TS*COS(T2):T4=TS*SIN(T2)
2150 T5=SQR(T3^2+T4^2)
2160 T6=2*ATN(T4/(T5+T3))
2170 T3=1-TS*COS(T2):T4=-TS*SIN(T2)
2180 T7=SQR(T3^2+T4^2)
2190 T8=2*ATN(T4/(T7+T3))
2200 T3=T5/T7:T4=T6-T8
2210 U5=1/(T3*Y0*COS(T4)):U6=1/(T3*Y0*SIN(T4))
2220 T3=SQR((U5-Z0)*Z0):U7=1/(2*PI*FR*T3)
2230 T4=(Z0^2+T3^2)/T3
2240 T5=1/(2*PI*FR*T4)+1/(2*PI*FR*ABS(U6))
2250 U8=1/((2*PI*FR)^2*T5)
2260 RETURN
2270 Q1=HM-R1:Q2=FM-R2
2280 IF Q1>=0 THEN D$="OUTSIDE" ELSE D$="INSIDE"
2290 IF Q2>=0 THEN E$="OUTSIDE" ELSE E$="INSIDE"
2300 RETURN
```

power gain other than G_{MAX} is desired for an unconditionally stable amplifier, or for determining source and load terminations for a potentially stable amplifier. Any reflection coefficient that falls on the circumference of a constant-gain circle can be used when designing a stage for that particular gain. That fact is particularly useful when designing wideband amplifiers, where it is necessary to design a matching network that intersects particular gain circles at many frequencies. The gain circles are determined by the following equations. **Eq. 5** determines both magnitude and phase of the center of the constant gain circle on the output:

$$C_{CG} = \left[\frac{G}{1 + D_2 \bullet G} \right] \bullet C_2^* \qquad \textbf{(5)}$$

where: $D_2 = |S_{22}|^2 - |\Delta|^2$

$G = \dfrac{10^{(0.1\, G_d)}}{|S_{21}|^2}$

G_d = *desired gain (DB)*

C_{CG} = *center of constant gain circle*

The radius of the constant-gain circle is determined by **eq. 6**:

$$R_{CG} = \frac{\sqrt{(1 - 2K\,|S_{21} \bullet S_{12}|\,G + |S_{12} \bullet S_{21}|^2 \bullet G^2)}}{1 + D_2 \bullet G} \qquad \textbf{(6)}$$

where R_{CG} = *radius of the constant-gain circle.*

Because an infinite number of load impedances fall on the constant-gain circle, it will be necessary to plot the constant gain circle on a Smith chart to select a proper load impedance. Once the load impedance is selected, the value of the source impedance that simultaneously matches the input is determined by **eq. 7**:

$$\Gamma IN = \left[\frac{S_{11} - \Delta \bullet \Gamma OUT}{1 - S_{22} \bullet \Gamma OUT} \right]^* \qquad \textbf{(7)}$$

where ΓIN = *reflection coefficient of the source impedance*

ΓOUT = *reflection coefficient of the load impedance*

mismatching

When a device is found to be only potentially stable *(K < 1)* the mismatching technique can be used to stabilize the device. The stage gain will determine the source and load terminations, and must be less than the maximum stable gain computed in **eq. 8**:

$$G_{MSG}(DB) = 10 \bullet LOG \frac{|S_{21}|}{|S_{12}|} \qquad \textbf{(8)}$$

Once the stage gain has been selected, **eq. 5** through

7 can be used to determine the constant-gain circle and the load and source reflection coefficients that result. All that is left is to design the input and output matching networks.

One problem associated with the mismatching technique is that the output return loss, S_{22}, is usually not very good (high VSWR). This could pose a problem when the amplifier is used to drive a filter, mixer, or transmission line. In the case of a bandpass filter, for instance, passband distortion would occur due to improper filter impedance termination. Also, high reactive impedances outside the passband could cause the amplifier to oscillate. The mismatching approach to device stability is best suited for interstage matching of two or more cascaded amplifiers.

output-shunt resistor

A stabilizing technique with many advantages (even in a single amplifier stage) is using a shunt resistor on the output of the device. A proper shunt resistor will prevent the device from becoming unstable no matter what the load or source impedance. The only cost trade-off is reduced gain. The stage will also exhibit very good input and output return loss (S_{11} and S_{22}). When using this amplifier to drive (or terminate) a bandpass filter, the passband will not be distorted and no reactive impedance will cause the amplifier to become unstable (provided $K > +1$ for all frequencies).

table 1. S-parameter and Y-parameter transformations.

$$S_{11} = \frac{(1 - Y_{11})(1 + Y_{22}) + Y_{12}Y_{21}}{(1 + Y_{11})(1 + Y_{22}) - Y_{12}Y_{21}}$$

$$S_{12} = \frac{-2Y_{12}}{(1 + Y_{11})(1 + Y_{22}) - Y_{12}Y_{21}}$$

$$S_{21} = \frac{-2Y_{21}}{(1 + Y_{11})(1 + Y_{22}) - Y_{12}Y_{21}}$$

$$S_{22} = \frac{(1 + Y_{11})(1 - Y_{22}) + Y_{12}Y_{21}}{(1 + Y_{11})(1 + Y_{22}) - Y_{12}Y_{21}}$$

$$Y_{11} = \frac{(1 + S_{22})(1 - S_{11}) + S_{12}S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$$

$$Y_{12} = \frac{-2S_{12}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$$

$$Y_{21} = \frac{-2S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$$

$$Y_{22} = \frac{(1 + S_{11})(1 - S_{22}) + S_{12}S_{21}}{(1 + S_{11})(1 + S_{22}) - S_{12}S_{21}}$$

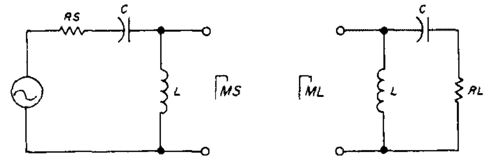


fig. 2. Computer designed input/output matching network.

The computer program determines the resistor value by calculating the new S-parameters of the device/resistor cascaded network. The stability factor, K, is then calculated. When $K > +1$, the proper resistor value has been found to make the stage unconditionally stable.

To determine the cascaded S-parameters, a transformation of the original S-parameters to Y-parameters is necessary. The device's output admittance (Y_{22}) and the equivalent admittance of the shunt resistor ($1/R_{SHUNT}$) are added together. The new Y-parameters are then converted back to S-parameters, which are now cascaded network S-parameters. Both transformations use the equations presented in **table 1**.

After the shunt-resistor value has been determined, the computer program will calculate the input and output reflection coefficients for maximum stage gain. For a specific gain less than G_{MAX}, the program can be iterated while varying the value of the shunt resistor, or, the constant-gain-circle design approach can be used.

matching network

To complete the computer-design package, a form of matching network has been included. This network is a two-pole, highpass filter (shown in **fig. 2**). This network was chosen because: it has a unique solution and is easy to calculate; it provides for easy input/output dc biasing; and it can match most transistor input/output requirements. **Fig. 3** shows the range of input and output reflection coefficients this two-pole network can match to the center of the Smith chart. The area where matches can occur is highlighted by the vertical lines.

Other configurations of the two-pole matching network could be programmed to design matching networks for the reflection coefficients falling in the other half of the Smith chart. The design equations for the network in **fig. 3** are listed in the **appendix**.

design example

The previous explanation was presented to give an idea of the capability of the computer program. How-

ever, whether you understood the theory or not, we are all on equal ground because the computer will do the work from here on.

A Motorola MRF-904 transistor was selected as a design example (because I had one available). The device has some characteristics making it a good choice for a preamplifier in the VHF and UHF bands, including low-noise figure, reasonable gain, and low cost. The design example that follows uses the MRF-904 as a single-stage preamplifier for 435 MHz with the thought that it would be used for OSCAR reception.

The design begins by determining the S-parameters for the operating conditions desired. The Motorola data book gives the S-parameters at 200 and 500 MHz. To get a reasonable estimate of the S-parameters at 435 MHz, a straight-line approximation was used to interpolate the needed S-parameters. **Table 2** lists the operating characteristics and S-parameters arrived at for 435 MHz.

When those S-parameters are entered into the computer, the initial evaluation of the device results in the following information:

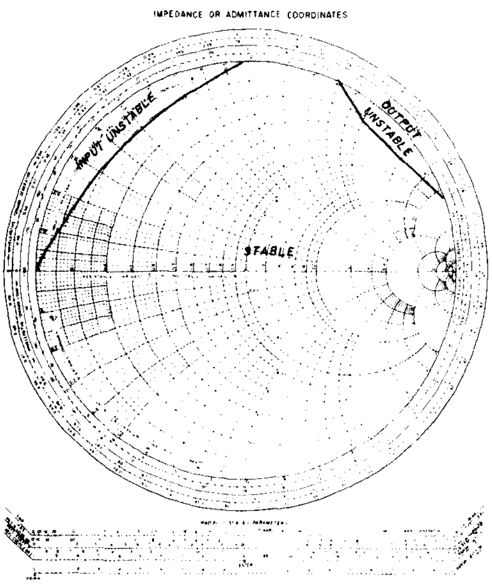


fig. 4. Stability circles for MRF-904.

table 2. MRF-904 device characteristics.

V_{CE}	I_C	S_{11}
6.0 volts	5 mA	$0.35\angle -63^\circ$
S_{12}	S_{21}	S_{22}
$0.084\angle 64^\circ$	$5.2\angle 93^\circ$	$0.66\angle -27^\circ$

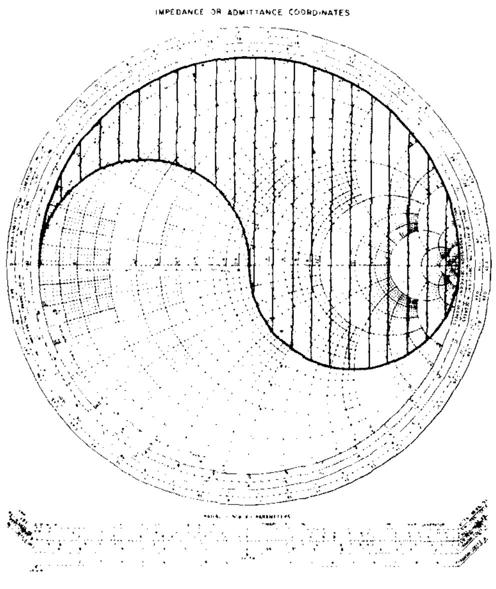


fig. 3. Transformable reflection coefficients.

$K = 0.875$ $\qquad G_{MSG} = 17.91\ dB$

Center of the input-stability circle: $1.389\ \angle -44.75^\circ$

Radius of the input stability circle: 2.178 INSIDE

Center of the output-stability circle: $4.779\ \angle 42.15^\circ$

Radius of the output-stability circle: 3.879 OUTSIDE

Since $K < 1$, the device is potentially stable and the maximum stable gain is 17.91 dB. The stability circles can be plotted on a Smith chart to graphically show the areas of device stability. The words Inside and Outside that follow the radius of the stability circles determines whether the inside or outside of the circle is the stable region. **Fig. 4** shows the stability circles for the MRF-904.

shunt-resistor approach

The next step is to choose to stabilize the device by a shunt resistor on the output, or by mismatching (using gain circles). With the shunt resistor approach, an arbitrary value can be used to start the stabilization process, and the value of the resistor lowered each time until $K > +1$. A resistor value of 300 ohms was chosen, which stabilized the device with the following results:

$K = 1.216 \quad G_{MAX} = 15.1\ dB \quad G_{MSG} = 17.91\ dB$

$\Gamma MS = .463\ \angle 92.21^\circ \qquad \Gamma ML = .554\ \angle 48.21^\circ$

The device, with the shunt resistor of 300 ohms, is now unconditionally stable with a gain of 15.1 dB.

The next step is to design the input and output matching networks. **Fig. 5** shows the device and matching networks. The component values in **table 3** are the result of the computer-calculated matching-network design. This completes the design of the amplifier using the shunt-resistor approach.

mismatching approach

To compare the mismatching technique to the shunt-resistor approach, the designed stage gain should be set at 15.1 dB as before. The first step is to determine the gain circle for 15.1 dB:

Center of the constant-gain circle = $0.567 \underline{/42.15^\circ}$

Radius of the constant-gain circle = 0.527

A reflection coefficient must be chosen that is on the circumference of the constant-gain circle. In order to do this, the constant-gain circle needs to be plotted on the Smith chart. One quick way to arrive at a load-reflection coefficient without the use of a Smith chart is to take the difference between the magnitude of the center of the gain circle and the radius. If this point falls in the transformable region shown in **fig. 3**, it can be used as the load-reflection coefficient. (If a load-reflection coefficient is chosen that does not fall in the transformable region, the computer program will stop with an error message.) The load-reflection coefficient of $0.04\underline{/42.15^\circ}$ was arrived at in this manner for the design example.

table 3. Input/output matching networks.

input network	output network
C_3 = 10.3 pF	C_4 = 5.23 pF
L_3 = 14.55 nH	L_4 = 20.85 nH

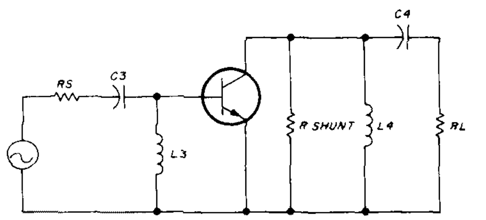


fig. 5. Computer designed matching networks, shunt-resistor type.

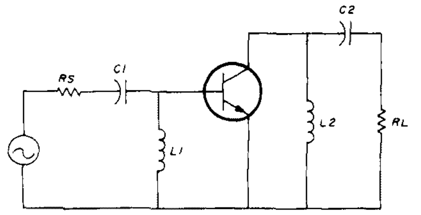


fig. 6. Computer designed matching networks.

table 4. Input/output matching networks.

input network	output network
C_1 = 9.45 pF	C_2 = 29.24 pF
L_1 = 19.53 nH	L_2 = 63.94 nH

The input-reflection coefficient was then calculated by the computer to be $0.348\underline{/65.92^\circ}$. The input and output matching networks can now be computed. The circuit will look like that in **fig. 6**, which is the same as **fig. 5** without the shunt resistor. The component values calculated by the computer for the mismatching case are listed in **table 4.**

performance comparison

The results of the two computer design approaches have been verified using Super-Compact™, an advanced engineering computer-aided-design program. The predicted performance data of the two amplifiers is shown in **figs. 7** through **12. Figs. 7, 9,** and **11** are for the shunt-resistor case, and **figs. 8, 10,** and **12** are for the mismatching case.

The data points out some of the characteristics of the two approaches. Two important differences that can be seen from the performance curves is that the gain (S_{21}) curves are different and the output return loss (S_{22}) is not as good for the mismatching case (**fig. 12**) as for the shunt resistor case (**fig. 11**). For the mismatching case, the gain will not necessarily be maximum at the design frequency; however, for the shunt-resistor case it always will. In either case, the gain is the same at the designed center frequency, and more importantly, it is what the computer was asked to design. The computer program is capable of calculating values for an amplifier stage using either approach, but from a performance standpoint the shunt-resistor approach appears better for a single-stage application.

conclusion

The results show that, with either design approach, the computer program can design the amplifier stage with a high degree of accuracy. In addition, the shunt-resistor approach should be of particular interest to Amateurs because a device can be made unconditionally stable, therefore any mistuning of the amplifier stage will not cause it to oscillate.

A complete listing of the computer program is in

fig. 1. It was written to run on a TRS-80 Color Computer, but should run on most other home computers with little or no modification. When you are ready to try your hand at amplifier design, grab a device and put your computer to work.

bibliography

Carson, Ralph S., "High Frequency Amplifiers," John Wiley and Sons, New York, 1975.

Froehner, William H., "Quick Amplifier Design with Scattering Parameters," *Electronics*, October 16, 1967.

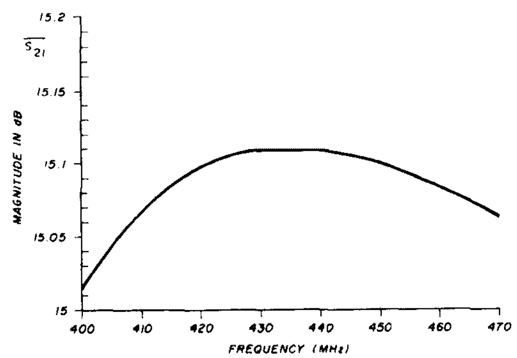


fig. 7. Gain using the shunt-resistor approach.

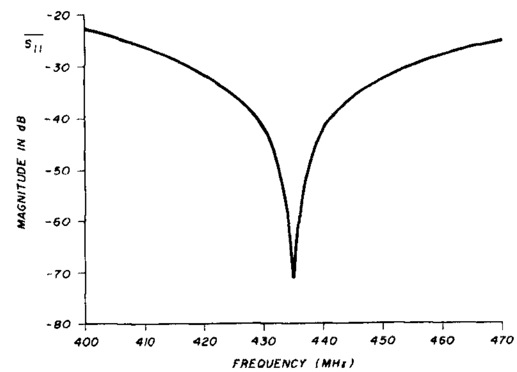


fig. 10. Input return loss for the mismatching approach.

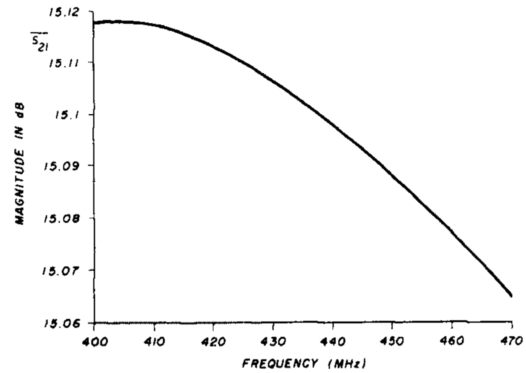


fig. 8. Gain using the mismatching approach.

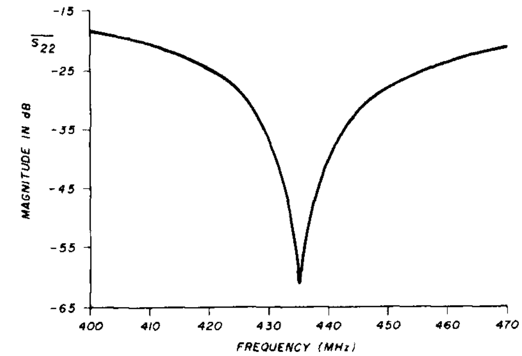


fig. 11. Output return loss for the shunt-resistor approach.

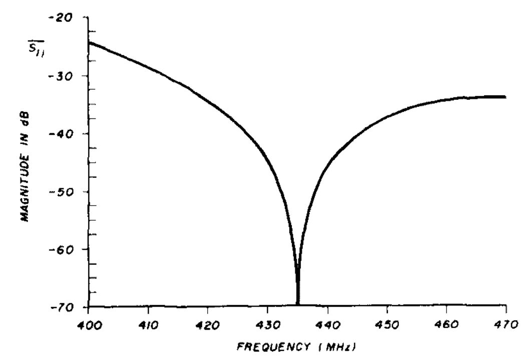


fig. 9. Input return loss for the shunt-resistor approach.

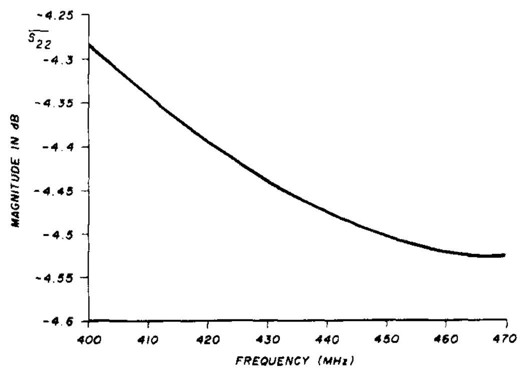


fig. 12. Output return loss for the mismatching approach.

Kraus, Herbert L., *et al*, "Solid State Radio Engineering," John Wiley and Sons, New York, 1980.

Jones, Marty, "High-Frequency Transistor Amplifier Design," *r.f. design*, September/October, 1981, November/December, 1981, January/February, 1982.

Shuch, H. Paul, WA6UAM, "Solid-State Microwave Amplifier Design," *ham radio*, October, 1976.

appendix

input/output matching network design

The first step in designing a matching network is to transform the reflection coefficient into an impedance or admittance. The first element used is a shunt inductor, therefore the reflection coefficient will be transformed into its equivalent admittance. To obtain the admittance form, it is necessary to add −180 degrees to any positive phase angle of the reflection coefficient, or add +180 degrees to any negative phase angle. The admittance is then found by using eq. 1:

$$Y_L = \left[\frac{1 + \Gamma ML'}{1 - \Gamma ML'} \right] \bullet Y_0 \qquad (1)$$

where Y_L = *transformed admittance*
Y_0 = *20 mmhos (for a 50-ohm system)*
$\Gamma ML'$ = *parallel equivalent of* ΓML.

In rectangular form, Y_L will have a real and imaginary component. The reciprocal of the real component corresponds to the resistance and the reciprocal of the imaginary component corresponds to the reactance.

The value for the series capacitor can be found from the following equations:

$$X_C = \sqrt{(R_P - R_S) \bullet R_S} \qquad (2)$$

where: R_P = *reciprocal of the real part of* Y_L
R_S = *system impedance (usually 50 ohms)*

$$C_{series} = \frac{1}{2 \bullet \pi \bullet F \bullet X_C} \qquad (3)$$

where: F = *amplifier design-center frequency*

The parallel equivalent of X_C is determined by eq. 4.

$$X_P = \frac{R_S^2 + X_C^2}{X_C} \qquad (4)$$

$$C_P = \frac{1}{2 \bullet \pi \bullet F \bullet X_P} \qquad (5)$$

where: C_P = *the parallel equivalent capacitance*

$$C_{IN} = \frac{1}{2 \bullet \pi \bullet F \bullet X_L} \qquad (6)$$

where C_{IN} = *the capacitance due to the transistor*
X_L = *the imaginary impedance component of the reflection coefficient*

$$C = C_P + C_{IN} \qquad (7)$$

The shunt inductor is then found by eq. 8:

$$L = \frac{1}{(2 \bullet \pi \bullet F)^2 \bullet C} \qquad (8)$$

This design procedure is implemented in the computer program, and is the same for the design of input or output networks.

ham radio

digital techniques: shocking truths about semiconductors

All the wonders of solid-state technology can be erased by either of two simple electrical sources: static electricity and supply-line spikes. Both problems can be eliminated with relative ease provided one is aware of the low breakdown voltages in semiconductors. Although this series of articles is on digital techniques, the same problems affect analog circuits.

Those trained in vacuum tube circuits understand the shock hazard to the worker. For most semiconductor circuits, the worker is the shock hazard! The designer may be the hazard by neglecting primary power source characteristics.

static electricity

A recent computer supply catalog stated, "A 7-second stroll across a carpet can generate 10,000 volts . . . ." The generated charge will vary widely with humidity and clothing, but a few hundred volts of static electricity discharged through a semiconductor can be a disaster. High-dielectric-constant fibers (polyester, nylon, acetate) can generate high-potential charges from friction.

The solution to the problem is to spread the charge across your working area to reduce both voltage and current through any device. The best practice is to *ground everything*, including yourself.

Several readers will now say, "Nonsense, I've been working with this stuff for years with no problems . . ." True enough, *most* of the time. The average experimenter will be working in comfortable clothes (older, probably cotton and including a bit of perspiration) on a less-than-clean work area (lossy dielectric) and during medium to high relative humidity. Static generation under these conditions is slight and dissipates well.

By Leonard H. Anderson, 10048 Lanark Street, Sun Valley, California 91352

Now try working in clean, polyester clothing on a clean plastic worktop while sitting on a plastic-fiber pad. In a dry atmosphere, just sliding off the pad will let you draw a quarter-inch arc to a metal object. A similar example is familiar to drivers in the north — sliding off seat covers will give an audible zap on touching a metal door handle.

setting up a better work area

My assembly work is done on a large, grounded aluminum plate taped to the bench top. An unpainted chassis cover plate is suitable. The building codes in my area require metal conduit for all ac power distribution. The conduit is grounded to both soil and water pipes. Each of my soldering irons is a *three-wire, grounded* type, and all test equipment has a ground strap to the work plate. **Fig. 1** gives a general idea of the workbench area.

Grounding test equipment may seem unnecessary until one checks ac leakage between units using a multimeter; some leakage can destroy CMOS devices. In non-conduit ac distribution installations, the ground wire connection should be checked on outlets; old, two-wire systems should have an extra ground line.*

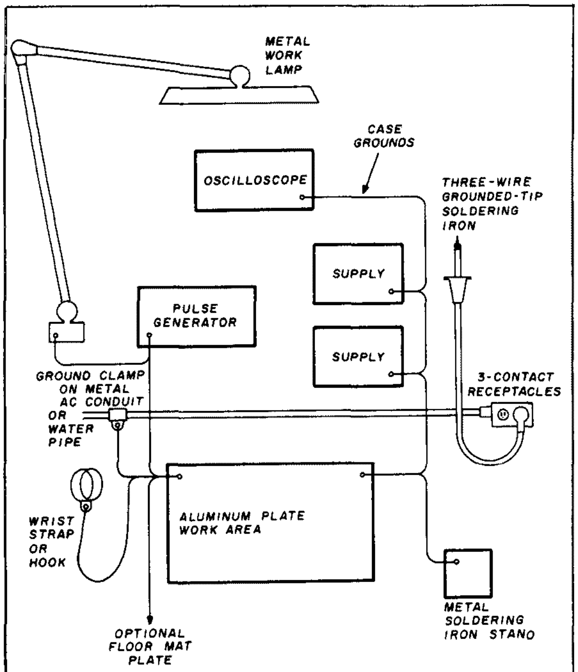


fig. 1. Layout and grounding of a static-free work area. Ground should be common to workshop's ac ground. Wrist strap and anti-static floor mat are optional.

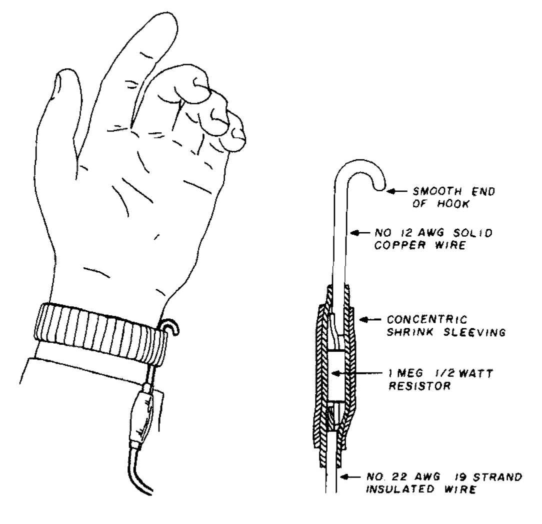


fig. 2. Wristwatch-band grounding hook used by the author. Insulated grounding wire is connected to work-area ground.

Anti-static plastic mats and storage containers are useful and can be obtained from suppliers given in the appendixes. The important point for static suppression is to provide a common charge collection point in body-movement areas.

ground yourself

Frequent touching of the common ground point is necessary to bleed off body charges. An alternative is to use a *high-impedance* wrist strap. High impedance is essential to prevent static charges from entering powered-up equipment. One megohm is a good value for 117-volt ac lines or 2.2 megohms for 220-volt ac lines.

I use a wristwatch-band hook as shown in **fig. 2**. The hook, which is made from a piece of No. 12 AWG solid copper wire, has an inside diameter about twice the watch-band thickness. Shrink sleeving encloses the nineteen-strand ground wire (multi-strand for safety) and the 1-megohm resistor. A banana plug and jack are used as a quick-disconnect to save the watch in case you forget about the hook being attached.

If neither is acceptable, try to wear natural-fiber clothes and use a metal bench stool. Experiment during low humidity for the least static charge buildup.

keeping components safe

Unmounted devices should be placed in black, *conductive* foam, whose resistance should be a few kilohms per inch. *Never* use nonconductive foam. Anti-static foam is acceptable for mailing; however, conductive foam is preferred over surface-treated nonconductive foam. Conductive foam is sometimes available at local electronics stores.* Antenna and microwave specialists can obtain scraps of Emerson and Cuming Eccosorb™ foam; most types are conductive.

Anti-static bins, envelopes, and plastic dual-inline carriers provide good protection for devices. The containers should be grounded when inserting or removing devices. Anti-static coating may be destroyed after repeated handling. Aluminum foil is unwieldy to use but is effective.

power-line spikes and transients

Power source input protection seems to be neglected by many experimenters and professionals. Transients from power lines seldom affect vacuum-tube power supplies but can damage or couple through solid-state supplies. The difference lies in breakdown voltage ratings of supplies and the source potential. Alternating current power lines can have transient peaks of 6 kilovolts; automobile battery lines can have 300-volt peaks.

General Electric's *Transient Voltage Suppression Manual*[1] contains much useful data on power-source transients. The main cause of transient generation is switch opening and closing in circuits containing transformer, motor, or solenoid inductances. **Table 1** is a listing of peak ac line spike voltages in the United States. On 220-volt ac lines these spikes can reach 10-kilovolt peaks.

Power-line radio frequency interference (RFI) filters can't handle most of the transients since their milliseconds duration puts spike power below cutoff. Automotive alternator field decay (ignition turn-off) can

table 1. Frequency of occurrence of ac power-line transient peaks in the United States. The data was interpreted from reference 1 and is a composite of industrial and residential service.

transient peak (kV)	number of transient occurrences per year
0.4	4000
0.6	800
1.0	150
2.0	30
3.0	9
4.0	3
5.0	1
6.0	0.4

*This safety measure should also be used with your rig or heavy appliances.

*I have yet to find a source that sells to individuals. Readers are invited to let *ham radio* know if such a source exists so that all can benefit.

peak to 300 volts over a 0.2-second duration.

One of the best protectors is the voltage-variable resistor, or *varistor*. A varistor is voltage-bipolar with a high impedance below breakdown voltage. Resistance is inversely proportional to applied voltage above breakdown. The General Electric GE-MOV™ metal oxide varistor and General Semiconductors' TranZorb™ devices work very well at *nanosecond* speeds.[2]

High voltage zeners and series blocking diodes are generally too slow or, if fast, too expensive.

protection with easy installation

Outlet strips or plugs are available with both electromagnetic interference (EMI) filtering and surge suppression. Their cost ranges from $10 to $20 an outlet. A list of advertisers is given in the appendixes.

Specifications should be checked carefully for your particular application. Surge ratings are generally given in joules (watt-seconds) and apply *only* to the transient; the ratings for the filter, outlet, and breaker (if any) are only for normal loads.

If in doubt of surge values at your location, set up a resistive divider on the power line and use an oscilloscope to check the line with the oscilloscope's internal sweep trigger set above normal peak. Operate as many appliances as possible and watch the trace. Include everything: furnace (igniter and blower), air conditioner, washer, garage door controller, kitchen appliances, and your shop's own equipment. The best time to check the line is when the power company is switching its own load peaks; other users can contribute spikes.

You can expect transients in the 50 to 100 microsecond range on ac lines. As a rule of thumb, a joule (watt-second) rating can be peak voltage squared, divided by normal equivalent load resistance, then multiplied by time duration of the transient. A safer margin is to multiply peak voltage by outlet current rating by duration.

Fuses will never protect against transients. They are much too slow.

unexpected transient sources

Distributing capacitance in digital circuit boards is very good for the circuits. The supply regulator can be reverse-biased and damaged if the regulator's input voltage drops sooner than the voltage on the load side. A very simple cure is the reverse diode recommended by National Semiconductor in **fig. 3**.[3]

Transients caused by a solenoid or relay driver can be suppressed by the reverse diode shown in **fig. 4**. Upon current cutoff, the inductor's magnetic field collapses and generates a black EMF or reverse voltage up to thirty times normal holding voltage. A diode or varistor can dissipate the flyback voltage and allow the use of a relay driver with a lower breakdown voltage.[4]

The regulator protector *must* be a diode and both circuits must observe diode polarity. A varistor is voltage bipolar.

Any reactive circuit drive by on-off digital circuits is a potential peak voltage danger to the circuit. It is helpful to go back to the first pages of handbooks and review the step-function voltages and currents.

conclusion

Semiconductors are low-voltage devices. Static electricity is a problem but can be reduced to safe potentials. Some old-timers might have to change workbench habits. Supply-line transients exist but can be cured by varistor surge protectors. A circuit can generate its own transients when reactances are present. These problems and solutions apply to both analog and digital circuits.

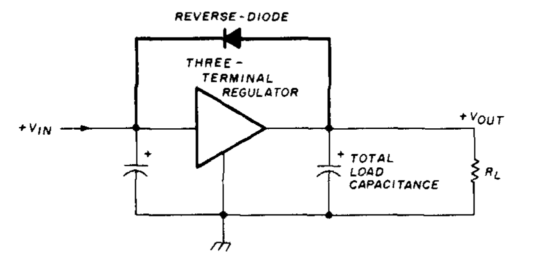


fig. 3. Reverse diode added to protect three-terminal regulators from reverse bias on turn off.

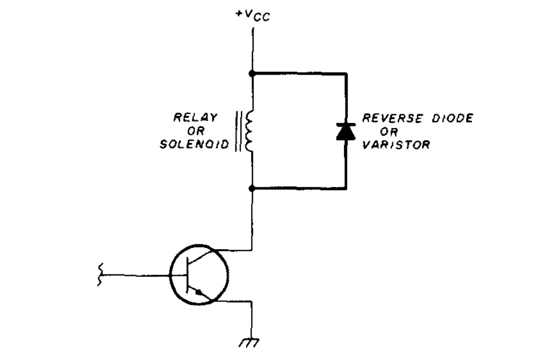


fig. 4. Reverse diode added to inductor to clip flyback voltage. Varistor can substitute for a diode but the diode's polarity must be the reverse of normal operating polarity.

references

1. *Transient Voltage Suppression Manual*, second edition, 1978, General Electric Company, West Genesee Street, Auburn, New York 13201. Still

available from representatives and distributors, it is well written and useful. Some data sheets on varistors are included.

2. General Semiconductor Industries, Incorporated, 2001 W. 10 Place, Tempe, Arizona 85281. Individual *TranZorb*™ data sheets are available from distributors.

3. National Semiconductor Corporation, Santa Clara, California. Either *Voltage Regulator Handbook* or *Linear Databook*, 1978.

4. William J. Prudhomme, WB5DEP, "Protecting Solid-State Devices From Voltage Transients," *ham radio*, June, 1978, pages 74-76.

appendix 1

computer supply distributors listing anti-static materials in mailed catalogs

Fidelity Products Company 5601 International Parkway P.O. Box 155 Minneapolis, Minnesota 55440	Plastic bags, mailers, work surfaces, covers, anti-static mats, aerosol spray, and surge suppressor ac outlets
INMAC 2465 Augustine Drive Santa Clara, California 95051	Anti-static mats, aerosol spray, and surge suppressor ac outlets
UARCO Computer Supplies 121 North Ninth Street DeKalb, Illinois 60115	Anti-static mats and bags
MISCO Inc. Box 399 Holmdel, New Jersey 07733	Anti-static mats, boxes, aerosol spray, and ac surge suppressors

Note: Aerosol sprays are intended for containers, furniture, and clothing. Effect on components is unknown.

appendix 2

manufacturers of surge suppressors advertising in magazines

R.L. Drake Company 540 Richard Street Miamisburg, Ohio 45342	Dymark Industries, Inc. 7133 Rutherford Road Baltimore, Maryland 21207
Electronic Specialists, Inc. 171 South Main Street Natick, Massachusetts 01760	Kalglo Electronics Co., Inc. Colony Drive Industrial Park 6584 Ruch Road Bethlehem, Pennsylvania 18017
Isobar™ GSC Electronic Corporation 25 Main Street Champlain, New York 12919	Sun Research, Inc. Box 210 New Durham, New Hampshire 03855 (dc-ac converter, used as uninterruptible power supply)
Powermaster™ SGS Waber Electric* 300 Harvard Avenue Westville, New Jersey 08093	MFJ Enterprises, Inc. Box 494 Mississippi State, MS 39762

The Newark Electronics 1981 catalog lists the following manufacturers:

GS Sola Electric	line voltage regulators
Superior Electric	Stabiline™ automatic voltage controllers
Adtech	CLIP-AC™ voltage clipper (10-50 microsecond response)

*Listed SGS Waber power outlets are convenience types only.

ham radio

matching 75-ohm hardline to 50-ohm systems

A single-stub tuner can bring 75-ohm low-loss to your system

By Lewis T. Fitch, W4VRV, 109 Robin Street, Clemson, South Carolina 29631

A number of schemes for using 75-ohm CATV hardline in Amateur 50-ohm systems have been published. These foam dielectric solid-shield cables have loss so low they are extremely attractive to the VHF operator, where tower heights call for long cable runs and every dB counts. I obtained a 200-foot length of cable and ran into some interesting problems when integrating it into my system.

A non-synchronous transformer[1] for six meters worked very well, but when line lengths were calculated for the higher bands, the line lengths (0.08 wavelength) became very short. Since a small length error could cause a large impedance difference, any possibility of using a coaxial switch as part of the 50-ohm system was ruled out. Simple L-C networks weren't the answer because some of the capacitor sizes necessary for such low impedance transformations turned out to be unwieldy. A quick calculation of the textbook classic[2] single-stub tuner showed that not only would the line lengths be long enough to be non-critical, but a coaxial switch could be incorporated into the network as a piece of the 50-ohm line, allowing band-switching for a single line.

The principle of the single-stub tuner is that for a

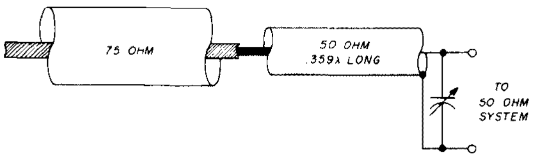


fig. 1. One-band 50- to 75-ohm match.

mismatched load a pair of points exist at two distances from the load where the real part of the input admittance is a match to the line. The capacitive or inductive part of the load at that point can be cancelled. Admittance is used for this calculation because on coaxial systems the parallel configuration is easiest to realize. This tuner gives a good match over a ±5 percent bandwidth, so once it is set it will match over the used portions of the VHF and UHF bands without adjustment.

The admittance cancelling stub is usually described in textbooks as made from a piece of transmission line. A real stub made from transmission line does not allow much adjustment. The stub only serves as a capacitor or inductor, so a variable capacitance could be used and could be adjusted to compensate for minor discrepancies elsewhere in the system. This form does not show up in the textbooks because it does not illustrate a pure transmission line problem, but its electrical operation is identical. Since a capacitor is used for the shunting element, the transforming line should be chosen to present a parallel inductive term at the matched resistance point. This one-band matching system is shown in **fig. 1**.

Calculating the actual lengths to do this on the Smith Chart (**fig. 2**), the 75-ohm line is entered as a conductance of $50/75 = 0.66$ on the 50-ohm transforming section. It can then be seen that if the 50-ohm line is 0.359 wavelength long, the input admittance at that point is $(1 - j0.4) \times (20\ millimhos)$. The 1 represents the resistive match and $-j0.4$ represents the part to be tuned out. A capacitor of $C = 0.008/2\pi f$ will do this, where f is in MHz and C in microfarads. The physical length of the line depends on its dielectric, so the best way to set its length is to grid dip it to a 1/4 wavelength resonance at the frequency that corresponds to the 0.359 wavelength found above (the results are shown in **table 1**).

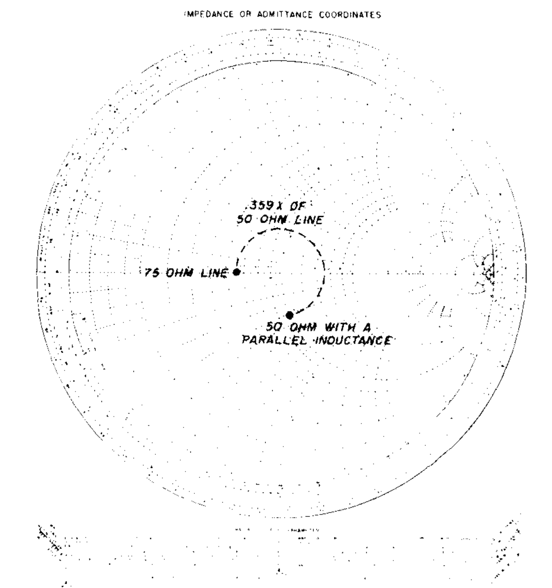


fig. 2. Impedance or admittance coordinates.

If the capacitor installed is variable with a higher

table 1. Smith Chart calculations.

frequency	length of RG-8/U (solid polyethlene dielectric)* inches		¼ λ resonance (all cables) MHz	C in pF
28	100	(2.53 m)	19.48	45.4
50	56	(1.42 m)	34.80	25.4
146	19-1/8	(0.486 m)	101.60	8.7
222	12-5/8	(32 cm)	154.00	5.7
432	6-1/2	(16.5 cm)	302.00	2.9

*Foam dielectric cables will be longer.

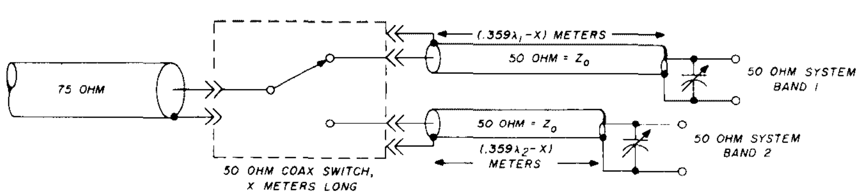
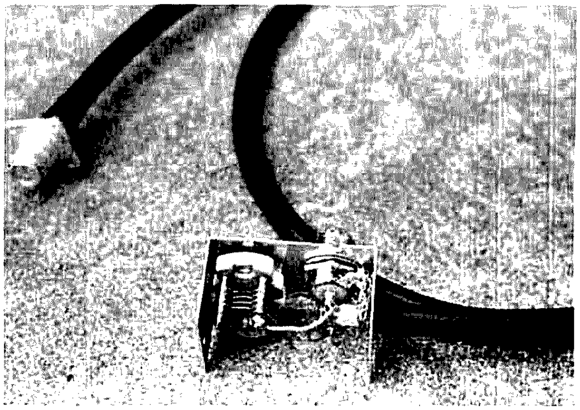


fig. 3. A multi-band system.



The six meter 75- to 50-ohm impedance converter.

capacitance than called for, some trimming may be done to compensate for small errors elsewhere in the system. In the device I finally constructed, a small mini-box was used to mount both the capacitor and the coaxial connections. The photo shows the finished 6-meter transformer.

Since the 50-ohm line connects directly to the 75-ohm line, a 50-ohm coaxial relay can be used as part of the matching system, and its length subtracted (or the tuning corrected for) from the line length listed.

Fig. 3 shows the 2-band connection with a relay. The length of line the relay replaces is shown as X.

Probably the best way to determine X would be to include the relay (switched to the desired position) in the grid-dipping operation. The frequencies in **table 1** are the same, but the line length will now include the relay length.

At the point where the capacitor is connected, the VSWR is 1:1, so the voltage across the capacitor is the voltage across a 50-ohm line. For a full rms kilowatt input to the system, the capacitor voltage at peak is 333 volts. A receiving-type capacitor could be used for most Amateur installations. The voltage at the point of connection to the 75-ohm line is 1.5 times that value, still not beyond the rating of RG-8. Two of these systems, constructed and put into use during the last year, work well. One is in an Amateur installation where the match to the antenna is a non-synchronous transformer at the top of the tower, and the other is in an fm broadcast installation where a solid-state amplifier required a very good 50-ohm match. In each case, the final value of VSWR could be adjusted to less than 1.05 to 1.

references

1. Charles J. Carroll, K1XX, *ham radio*, September, 1978, p. 31.
2. *Lines, Waves and Antennas*, Browne, Sharpe, Hughes and Post, Wiley Publishing Company.

ham radio

bridged-T filters
for Amateur use

Design data for a versatile circuit

Notch and peaking filters are useful in many Amateur applications. You may, for example, notch out 60-Hz or 120-Hz hum, peak up a particular CW note, notch out an undesired signal in a 455-kHz i-f stage, furnish additional rf preselection in multi-transmitter contest stations or where strong locals operating on other bands are bothersome, and reduce harmonics and TVI.

The bridged-T filter is a particularly nice filter choice. Unlike the T and pi, it shares a constant image impedance at all frequencies with the lattice. Also, it is unbalanced to ground and can therefore be used in coaxial-line and other grounded circuits. Finally, it has fewer components than other types. The response, maximum attenuation, and other factors (except image impedance) of the bridged-T are comparable with other filter types.

standard design relationships

Design relationships for bridged-T filters are well known, and published in many texts (see, for example, references 1, 2, and 3). These relationships, however, usually assume that you are looking for a prescribed attenuation characteristic, and they give the impression that the design is always physically possible. For example, in the circuits shown in **fig. 1**, values for resistors R1 and R2 might be impossible to achieve with inductances of finite Q.

These standard design relationships are not especially convenient when you have some inductances and capacitors available and wish to construct a filter from them. In such a case you might be willing to accept whatever attenuation you can get and use whatever image impedance is necessary.

using inductance Q

It is simpler to structure the relationships by basing them on the Q of the available inductances, as has been done in **fig. 1**. Q is the one characteristic of inductance more easily measured than any other. It is also convenient to make the inductances equal to each other, which also makes the capacitors equal to each other. While there is a slight advantage in response sharpness when the inductances are not equal, this is more than offset by the problem of finding odd-sized components.

When you proceed in this way, you need find only a *single value* of L and a *single value* of C. Also, with equal inductances, the attenuation of the filter simplifies greatly, and the maximum rejection, as well as the sharpness, is entirely dependent on the Q of the coils. Also, a lot of calculation is not necessary; finding the component values is a simple matter of proportional multiplication, which can be done on any four-function calculator.

table 1. *Equal-L and equal-C values illustration.*

f_r	R_o (ohms)	L	C
60 Hz	100	0.265 H	26.530 μF
120 Hz	100	0.133 H	13.270 μF
400 Hz	100	40 mH	3.979 μF
500 Hz	100	32 mH	3.183 μF
1000 Hz	100	16 mH	1.592 μF
455 kHz	100	0.035 mH	3497.9 pF
455 kHz	1000	0.350 mH	349.8 pF

To illustrate, the equal-L, equal-C case has L and C values for some representative frequencies as shown in **table 1**. As we double the frequency from 500 to 1000 Hz, the value of L is halved, as is the value of C.

By **R.W. Johnson, W6MUR,** 2820 Grant Street, Concord, California 94520

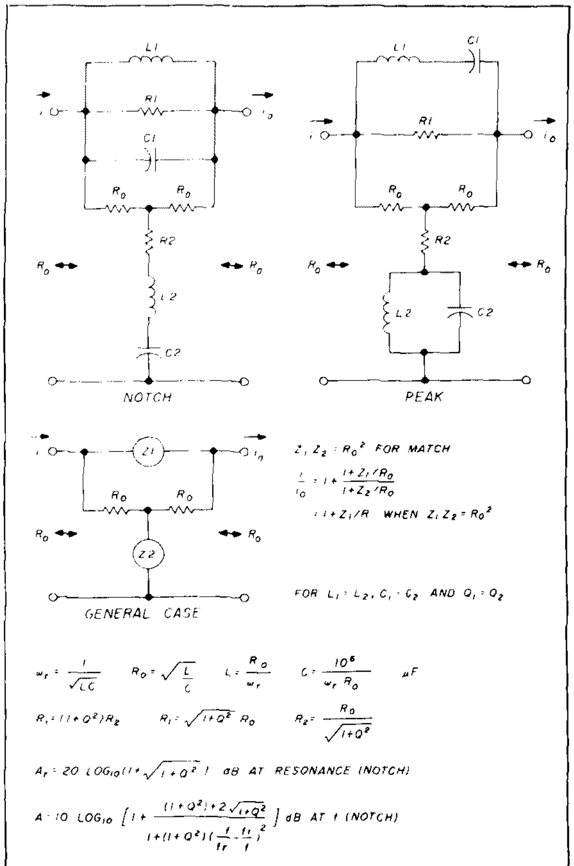


fig. 1. Basic bridged-T circuits and their relationships.

If we raise the image impedance R_0 ten times, the value of L goes up ten times, but the value of C is reduced to one-tenth. To go to 500 Hz from 400 Hz, multiply $40 \times (400/500)$ to get 32 mH for L, and do the same with $C(3.979 \times 400/500 = 3.183\,\mu F)$.

Say you have two fairly high-Q 88-mH toroids and want to construct a 500-Hz peak or notch filter. What R_0 must be used? For $R_0 = 100$ *ohms*, $L = 32$ *mH*: simply multiply $100 \times (88/32) = 275$ *ohms*, and this is the R_0 you would have to settle for. C becomes $3.183 \times (32/88) = 1.57\,\mu F$.

The maximum attenuation of a notch filter at resonance, or a peaking filter far from resonance, is dependent on the Q, as is the sharpness, in the equal-L, equal-C case. The relationship is simple:

$$A_r = 20\log_{10}(1 + \sqrt{1 + Q^2})\,dB \qquad (1)$$

A plot for this is shown in **fig. 2** (lower curve). If your coils have a Q of 100, you can expect rejection notches no deeper than 40 dB. If you are stuck with a Q of 5, only 15.7 dB is possible, and you might as well not use a filter! If you need 60 dB, you will need a Q of 1000 with a single filter, which is mighty hard to find!

impedance considerations

The constant image impedance of these bridged-T filters means they can be cascaded or placed in tandem, even if they are tuned to different frequencies. When terminated in R_0, the input impedance of the filter is R_0 at all frequencies, provided that the product of Z_1 (the bridging impedance) and Z_2 (the shunt impedance) is equal to R_0^2 and is independent of frequency. This is why one impedance is the dual of the other, one being series resonant at f_r and the other anti-resonant at f_r. The square root of the product of the two impedances is a pure resistance for reasonably high Q (if Q = 5 or more).

The same component values apply for peaking filters. Only the connections change, as shown in **fig. 1**. The attenuation curves for the same Q are upside-down mirror images of each other. A_r in **fig. 2** is now the maximum attenuation that is obtained at zero and infinite frequency. Remember that peaking is actually a misnomer because the filter has no gain; it simply rejects frequencies away from resonance. There is a very slight insertion loss due to the finite Q of the coils, and some energy must be lost heating up these resistors. This loss is less than 1 dB for Q = 10, however.

notch-filter example

A notch filter for 50-ohm receive antenna lines is shown in **fig. 3**. Since Qs of 200 or so can be obtained without too much difficulty, it is clear that some 46 dB of attenuation at the notch can be obtained. If you need more, use higher Q coils or tandem more than one filter. The filter in **fig. 3** is intended for use in multi-transmitter contest stations, to reject signals from another band that might be bothersome.

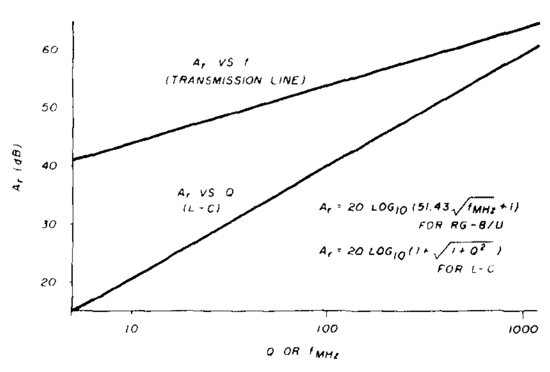
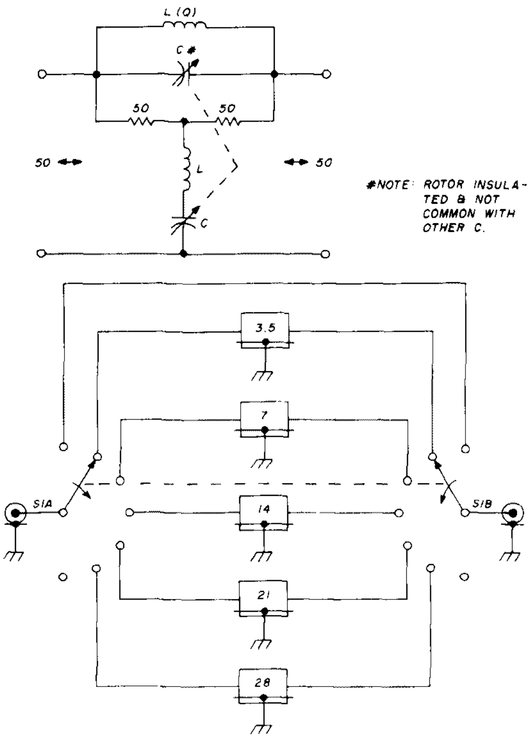


fig. 2. Maximum attenuation of notch filters.



BAND (MHz)	L (µH)	C_{max} (pF)
3.5	2.27	910
7	1.14	460
14	0.57	250
21	0.38	160
28	0.28	120

fig. 3. Receive antenna line (50-ohm) notch filter for QRM from another band.

Although the capacitors in **fig. 3** are shown ganged, a better notch might be obtained by making them independently variable, or at least using a trimmer across one or both. Practical coils will not be identical, and their proximity to shields, etc., may cause them to be different even if they seem the same. Since the rotors of the two capacitors are not common (and only one is grounded), separating them is easy.

Don't try to use this filter for notching on the same band (for example, between CW and SSB segments), except possibly on 3.5 MHz. To notch on the same band, you need crystal filters, not discussed in this article.

You can get an idea of the sharpness of these bridged-T notch filters by noting the f/f_r for attenuation of half as many *dB* as A_r (see **table 2**). If you tried to use the filter between 3.5 and 3.8 MHz, for example, $3.8/3.5 = 1.0857$ and you would still have 15.85 dB of attenuation at the desired frequency with $Q = 100$. For other bands the situation is much worse (14.0 to 14.1 MHz, for example, even with $Q = 1000$ gives 36.9 dB loss at the desired frequency).

Watch the leakage and mutual coupling between coils; keep leads short and stray capacitance down; and shield the filter. Remember that no rejection filter is going to help if there is rf due to high VSWR on antenna feedlines, poor grounding and shielding, parasitics, and so on. These filters won't help the harmonics generated by nearby transmitters in a receive line either, although they will help those generated in the higher-band receiver due to overload.

transmission-line filters

One application for bridged-T filters seems to have escaped much attention. If the impedances Z_1 and Z_2 in **fig. 1** are transmission lines, each of the same electrical length, one shorted and one open, then the required condition of duality between the two impedances is obtained as long as the lines have reasonably high Q. Suppose, for example, that we use a shorted line for the bridging impedance, Z_1, and an open line of the same length for the shunt impedance, Z_2. Then, assuming infinite Q of the lines (no losses),

$$\begin{aligned} Z_1 &= j Z_{o1} \tan\theta \\ Z_2 &= -j Z_{o2}/\tan\theta \end{aligned} \tag{2}$$

so that $Z_1 Z_2 = Z_{o1} Z_{o2} = R_o^2$ is the condition for input impedance, being R_o when the filter is terminated in R_o, and this condition is independent of frequency. The response of the filter is given by the simple relationship

$$A = \log_{10}\left[1 + (kT)^2\right] \tag{3}$$

where $Z_{o1} = kZ_o$, $Z_{o2} = Z_o/k$, $Z_o = R_o$, and $T = \tan\theta$; θ being the electrical length of each equal-length line, for $k = 1$, $Z_o = R_o$ in both lines. If the lines are a quarter wave long ($\theta = 90$ *degrees*) **eq. 3** would in-

table 2. Sharpness table.

Q	f/f_r (A_r .2)*
5	1.27107
10	1.17897
20	1.12102
50	1.07395
70	1.06199
100	1.05151
150	1.04180
200	1.03607
300	1.02933
500	1.02263
1000	1.01594

*Also the reciprocal of this.

dicate infinite attenuation in the notch filter. This is actually not the case, as will be seen.

The maximum attenuation of a notch filter using quarter-wave lines is also related to the Q of the lines, but how we define this is important. Z_0 is no longer a pure resistance with a lossy line, but is complex. Also, the hyperbolic/exponential instead of the trigonometric functions must be used, and the argument in these is also complex. This gets somewhat messy analytically, but since we are really interested in the maximum attenuation of a notch filter at resonance (and at its odd harmonics), we can draw on Dr. Terman for the answer. Reference 3, page 191, eq. 66 gives the resonant impedance (resistance) of a shorted copper coaxial line that is an odd number (n) of quarter waves long. The equation takes into account the loss resistance of the line, but assumes air insulation (no dielectric loss). Applying this to 50-ohm, RG-8/U foam line, one obtains the simple result for the bridged-T notch filter (shown in **fig.** 4).

$$A_r = 20 \log_{10} (51.43 \sqrt{f_{MHz}} + 1) \qquad \textbf{(4)}$$

A plot of A_r versus frequency (not Q, but same scale as Q) is given as the upper curve in **fig. 2**. The attenuation would be less for, say, RG-58/U, more for 75-ohm cable (requiring a 75-ohm image impedance), and more for larger diameter lines.

The transmission-line notch filter does one thing no ordinary lumped-constant filter does. It acts as a notch filter at all odd harmonics, and a pass filter at all even harmonics. Conversely, a pass filter at f will become a notch filter at 2f, 4f, 6f, etc., and a pass filter at 3f, 5f, 7f, etc. Although the Q of a given electrical line length increases with the square-root of frequency, the depth of the notch does not, because the additional resistance of the longer line (in wavelengths) enters into the picture and the resonant impedance is actually inversely proportional to n, as can be seen from Terman's eq. 66 (see above). Some typical maximum attenuation figures in dB for the harmonics up to 1000 MHz in a notch filter using RG-8/U are given in **table 3**. The list is cut off above 1000 MHz because other errors, such as dielectric loss, imperfect shorts, lossy connectors, and so on, affect the results.

These transmission-line bridged-T filters would be useful to filter harmonics out of a transmitter. A pass filter (Z_1 being an open $\lambda/4$ line and Z_2 a shorted $\lambda/4$ line at the fundamental f_r) would pass f_r but stop all even harmonics, and pass (but not amplify) all odd harmonics. Placing it in tandem with another pass filter tuned to 1.5f would notch out 3f, 6f, 9f, etc., and produce an insertion loss at f of only about 3 dB. In this particular arrangement 5f, 7f, 11f, and 13f are missed, but other filters can be devised to catch these.

table 3. Typical attenation figures for notch-filtered harmonics

n (order of harmonic)	50	75	100	150	250	500
	f (fundamental, MHz) — attenuation (dB)					
1	51.2	53.0	54.2	56.0	58.2	61.2
3	46.5	48.2	49.5	51.2	53.5	
5	44.3	46.0	47.3	49.0		
7	42.8	44.6	45.8	47.6		
9	41.7	43.5	44.7			
11	40.9	42.6	43.9			
13	40.2	41.9				
15	39.5					
17	39.0					
19	38.5					

Even at 14 MHz a $\lambda/4$ coaxial line with $v_p = 0.66$ is only about 11 feet 7 inches long. Is your TVI worth 23 feet of coax?

The shield of the coax comprising Z_1 must float, creating problems at higher frequencies. One cure is to place the coax in a pipe of the same length, which has an inside diameter 2.3031 times the outside diameter of the Z_1 coax shield, as shown in **fig. 4**. This makes the shield the center conductor in a 50-ohm coax and solves the problem of the floating shield. Another solution is to make $k = 2$ and use two coax cables in series in a balanced configuration for Z_1, so that $Z_{01} = 100\ ohms$. Then, since the product $Z_{01}Z_{02}$ must be 50^2 or 2500, Z_{02} must be two coax cables in parallel for $Z_{02} = 25\ ohms$. Then the rf is confined to the inside of the shield in Z_1. This arrangement actually gives a bit higher attenuation as can be seen from **eq.** 3 for electrical lengths close to 90 degrees.

Even these filters are not sharp enough for in-band rejection. Lest you be tempted to use one in a repeater with 0.6-MHz frequency separation at 146 MHz, for example, you would find you still had over 44 dB of attenuation at the receive frequency! To

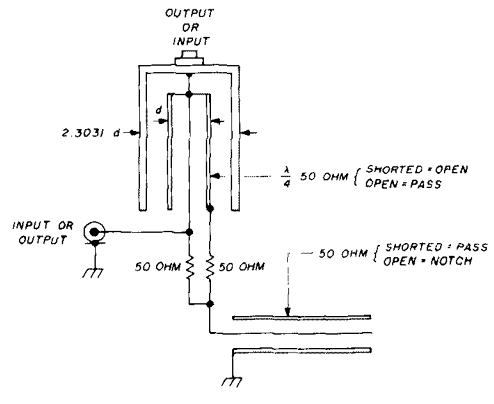


fig. 4. Coaxial line bridged-T filter.

reduce the insertion loss to 10 dB, even with lossless lines, you need about 25 percent frequency separation, for equal Z_0's.

For balanced 300-ohm circuits you would be better using the lattice equivalent of this filter. The text listed in reference 1 can provide details.

You will find that some line tweaking is required, using some sort of line stretcher or plunger tuning, to get the best null. A notch filter I assembled made of a piece of Andrew semi-flexible polyfoam line inside a piece of 1-inch copper plumbing pipe for Z_1 exhibited only about 35 dB of attenuation at 50 MHz when it should have been 51 dB or more. Displayed on a spectrum analyzer having peak hold and memory capability as a signal generator, slowly tuning across the band to 1000 MHz (keeping generator output voltage constant) showed the same multiple notches at odd harmonics that one would expect, and the same gradual lessening of the depth of the notch as frequency increased. With more precise tuning of Z_2 using a General Radio line stretcher, I was able to reach attenuation over 50 dB at the fundamental.

When you use these filters to notch out any appreciable energy, remember that at resonance Z_1 looks like essentially an open circuit and Z_2 like a short circuit. The input resistor R_0 therefore must dissipate all the energy to be rejected. If the harmonic to be rejected is only 30 dB down in a 2 kW transmitter (which is why you need the filter in the first place), you have about 2 watts of harmonic energy for 2 kW output. To play safe, even with 1 kW input and 60-dB harmonic attenuation in a good Pi-L output network, for example, use 2-watt resistors for R_0. Make sure they are carbon, non-inductive, and preferably 5 percent (51 ohms) or selected from available 56-ohm or 47-ohm 10 percent units. The shunt line Z_2 must withstand the rf voltage across a 50-ohm line at the fundamental, so it should be able to take at least 300 volts rms of rf. You could even use RG-223/U (better shielded than RG-58/U) for this impedance, although the loss will be higher than with RG-8/U or something better.

Bridged-T notch and peak filters are easy to design and highly useful around the Amateur station. Just remember to use as high a Q as you can if you want good rejection, and follow good construction practice when you build the circuits.

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1. Landee, Davis and Albrecht, *Electronic Designers' Handbook*, McGraw-Hill, 1957, pages 17-7 through 17-14.
2. D. Kimball, *Motion Picture Sound Engineering*, Van Nostrand, 1938, chapter 16.
3. F.E. Terman, *Radio Engineers' Handbook*, McGraw-Hill, first edition, 1943, page 191.

ham radio

operation upgrade: part 10

The tenth part in a continuing series designed to help you upgrade your ticket

This, our tenth article in the series to help you better understand the FCC license test questions, continues the discussions on antennas begun in Part 9. This in turn followed the basics of radiotelegraph transmitters and receivers, power supplies, active devices, ac circuits and dc circuits.

After basic information on wave travel, half-wavelength ($\lambda/2$) dipoles and $\lambda/4$ verticals, open-wire and coaxial transmission lines were considered, and an SWR meter was described. This month we will discuss some other basic antennas used by Amateurs, and which may form the basis of FCC license questions.

multiple-wire folded dipoles

The bandwidth of a 7-MHz-band dipole is not too broad. If your transmitter is tuned to the center of the band, 7.15 MHz, and the feed line SWR is 1:1, you may find the SWR at the band edges, 7 and 7.3 MHz, to be between 1:2 and 1:3. This indicates less power is being radiated at these band-edge frequencies. An

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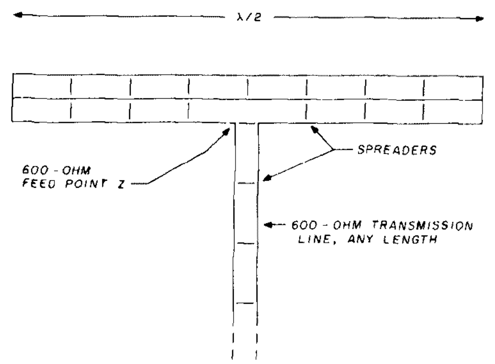


fig. 1. A three-wire folded dipole increases center feed point impedance nine times.

improved bandwidth will result from using an open-wire transmission line, $\lambda/2$ long and shorted together at the ends, as the radiating antenna element. If one of the two wires of such a folded dipole antenna is opened in the middle and its radiation resistance is measured, it will be found to be about 288 ohms. The formula for determining this impedance is $Z_0 = 72n^2$, where n is the number of similar sized wires used in the radiating element. A commonly available TV 300-ohm twin lead transmission line matches 288 ohms closely enough so that the SWR will be close to 1:1 (actually 300/288, or 1:1.04). If the SWR is checked at the band edges with this folded dipole, it will be found to be two or three times better than with a single thin wire dipole. (The thicker the radiating element the broader the bandwidth of an antenna.)

If a folded dipole of this type uses three parallel wires shorted together at the ends, and only one of the wires is cut in the center (**fig. 1**), the impedance at the feed point will be $72(3^2)$, or 648 ohms. This will match a 600-ohm open-wire line closely enough to produce a nearly 1:1 SWR also (648/600, or 1:1.08). A folded dipole like this operates as a broadly tuned antenna for any Amateur band for which it is cut. The 9-to-1 increase in center impedance over a dipole can be useful in close-spaced-element beams where the center impedance may approach 8 ohms because of the proximity of the other elements. By using a three-wire folded dipole as the driven element, it's possible to feed it with an 8-ohm times 9, or 72-ohm transmission line for a nearly perfect impedance match. The "flat-top" wires of folded dipoles must be held at a constant spacing by using insulating spreaders, or spacers between wires every 4 to 6 feet (1.5 to 2 meters). The number of inches of spacing is not too critical. The same 648-ohm center impedance can be obtained using a two-wire folded dipole if the unbroken wire has twice the surface area of the wire being fed at its center (effectively two wires in parallel).

mobile and trap antennas

Amateur mobile equipment may be HF, VHF, or UHF, using fm, SSB, or CW. In essentially all cases the antenna will be a vertical steel whip, usually an electrical $\lambda/4$ for the HF bands. In all cases the metal chassis of the vehicle operates as ground.

For HF band operation the antenna is usually mounted on the left rear bumper, or in that vicinity. (Right-side mounting tends to hit too many objects. If mounted in front it impedes vision.) Since most highway departments limit the highest point on a vehicle to 13.5 feet (4.1 meters), a 40-meter vertical (which would be approximately 33 feet long) must be inductively loaded. Either the center of the vertical whip is cut and a loading coil is added there to make up for the missing antenna length, or a loading coil can be added at the base of the antenna. In addition, wires mounted at the top of the whip and radiating outward, called a capacitive hat, have the effect of capacitively loading the antenna to a lower resonant frequency. If the antenna is mounted 2 feet (0.6 meters) above the ground, the vertical whip will be limited to 11.5 feet (3.5 meters). The loading coil will have to have about 33 − 11.5, or 21.5 feet (6.5 meters) of wire in it (actually somewhat less, determined by experimental trimming while using an SWR meter in the transmission line). Shortened antennas of this type may reduce the feed point impedance to the 10-ohm range. Using a 50-ohm coax feed line will result in an SWR of about 1:5, which is intolerable.

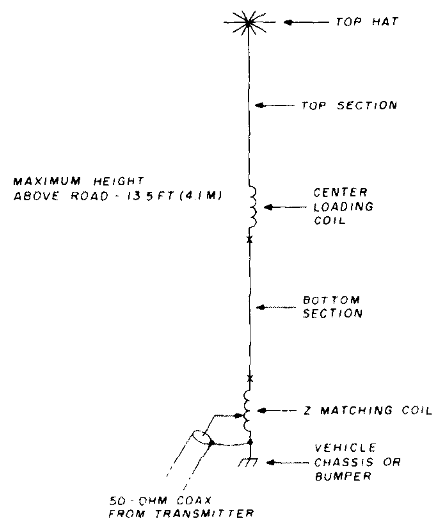


fig. 2. HF mobile whip antenna. Springs may be mounted at either point marked with an X.

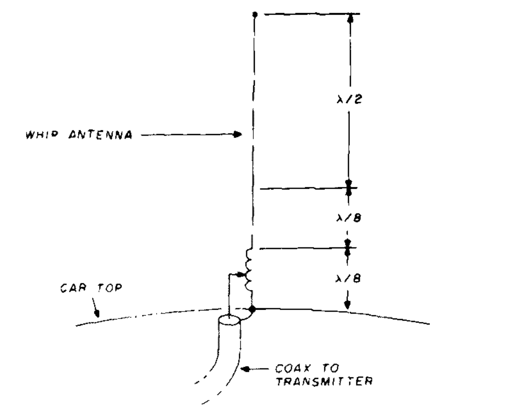


fig. 3. A 5/8-wavelength VHF/UHF mobile antenna.

Something must be done to match the feed line to the base impedance. One relatively simple and successful HF mobile antenna system is shown in **fig. 2**. The purpose of the five- to ten-turn impedance matching coil at the bottom is to allow you to find the 50-ohm point on the vertical antenna system to match the 50-ohm coaxial line. When the tap is set to the proper point the SWR will be at a minimum, assuming the loading coil also has the correct number of turns for the frequency to be used. A small capacitor inserted in the Z-match tap line may further reduce the SWR (the value is determined experimentally).

Mechanically, the loading coil must be strong enough to withstand the high wind pressures developed when the vehicle is in motion on a highway. The bottom of the lower section of the whip is fastened to a strong insulating mounting, usually on the rear bumper. The Z-match coil is connected between antenna bottom and the chassis. A stiff spring, shorted across by a copper braid, should be mounted at either of the points shown by an X in **fig. 2**. A bottom spring must be considerably stiffer than one mounted just below the center loading coil. The higher spring, being less stiff, permits the whip to strike objects with less force, and may change the tuning of the antenna less when the vehicle is in motion. When in motion, the antenna tilts backward and detunes somewhat.

In the VHF and UHF ranges the antenna may be a simple λ/4 vertical mounted in the center of the top of the vehicle, with coax fed from beneath the roof. Similar antennas may also be magnetically mounted on the top surface, with the coaxial cable running into the car through a window or door.

A popular mobile VHF/UHF antenna is the 5/8-wavelength (5λ/8) vertical. It is actually a 3λ/4 vertical, with the bottom λ/8 made up into a coil (see **fig. 3**). The proper matching impedance point for the coaxial impedance can be found by adjusting both the tap and whip length for minimum SWR. A 3λ/4 antenna of this type may also be fed directly by a 50-ohm coaxial line, with its braid or sheath connected to the car top and the inner conductor connected to the insulated bottom of the antenna.

The angle of maximum radiation of a λ/4 vertical is somewhat higher than that of the 5λ/8 antenna, resulting in a stronger signal being radiated parallel to the ground by the 5λ/8 antenna. A gain of about 2 dB over flat terrain may be expected from a 5λ/8 over a λ/4 antenna mounted on the same vehicle.

trap antennas

Trapped antennas are interesting devices. The antenna shown in **fig. 4** is a center-loaded type vertical antenna for the 7-MHz band. The loading coil is mounted at the point in the antenna which is the end of the λ/2 for the next higher Amateur band, 14 MHz. The coil acts as an rf choke at the higher frequency band, allowing the lower section to function as a vertical λ/4 at this higher frequency. A second coil can be added to make the antenna resonate on three different Amateur bands. If two of these trapped vertical antennas are mounted base to base and erected horizontally, the system will operate as two- or three-band horizontal dipoles. They may be fed by a 50-ohm coax line or a gamma match system (see next section).

beam antennas

The common horizontal λ/2 dipole radiates maximum energy at right angles to the line of the antenna wire, and zero energy off the ends of the wire. This can be indicated by the dashed circular lobes shown on the horizontal dipole in **fig. 5A**. The rays emanating from the center of the dipole indicate the relative strength of the radiated energy in the directions of the rays.

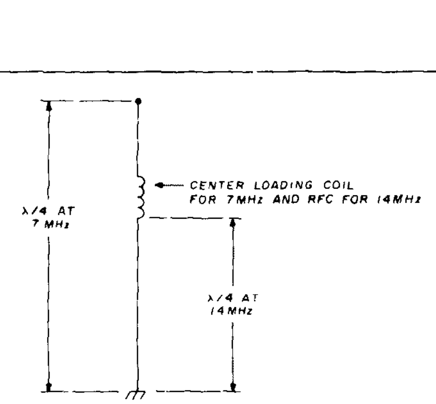


fig. 4. Basic idea of a two-band trapped vertical antenna.

The 3 dB (half power) beamwidth of this antenna is approximately 45° (from a ray length of 0.707 maximum, through maximum, to the other ray length of 0.707).

If a second $\lambda/2$ wire (element) is paralleled with the driven dipole element, as shown in **fig. 5B**, the radiation lobe narrows, but also lengthens, indicating greater energy radiation (about 4 dB more) at right angles to the driven element. The second element is not driven, but picks up energy from the driven element, changes it in phase, and reradiates energy back to the driven element. Both elements are now working to radiate energy forward (upward on the page) as well as backward, and a greatly reduced energy to the sides (out of, or into the page). This is known as a two-element parasitic beam because the second element is energized parasitically (inductively, not by any direct coupling).

If the parasitic element is made about 5 percent longer than the driven element and placed about 20 percent of a wavelength (0.2λ) from the driven element, another 1 dB of major lobe forward gain will be developed. Now energy to the back will be significantly reduced. We say the parasitic element is acting as a reflector. A third element added in front of the driven element, spaced about 0.15λ and made 5 percent shorter than the driven element, will add still another 1 or 2 dB of forward gain, reducing the backward radiation still more. The third element is called a director. Such an antenna is the popular three-element parasitic Yagi beam antenna used by many Amateurs, and also used as TV receiver antennas. If four or five elements are used, the added elements will be second or third directors in front of the first. They may be somewhat shorter and spaced at about 0.15λ from each other.

The more elements added to a beam antenna the narrower the beamwidth and the more forward gain

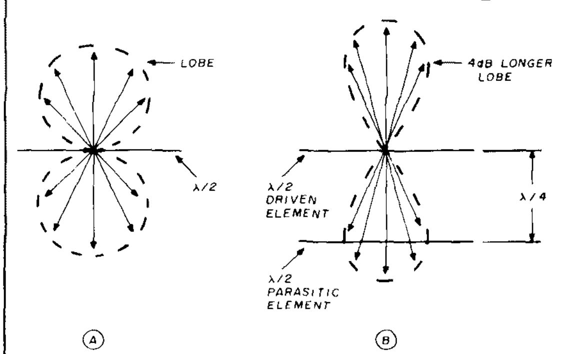


fig. 5. Radiation lobes for (A) a $\lambda/2$ dipole and (B) a $\lambda/2$ dipole with a parasitic $\lambda/2$ reflector/diameter element.

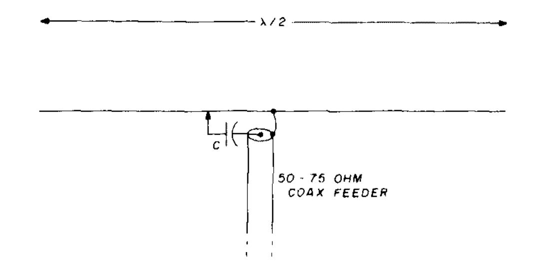


fig. 6. The gamma match method of coupling a coaxial transmission line to a $\lambda/2$ dipole.

produced. Also, the front-to-back ratio is increased as elements are added, which is an advantage. However, for every element added there will be small side lobes developed on each side of the major, or forward lobe. Yagis are relatively small antennas and are often made rotatable.

The greater the number of elements used and the closer they are to the driven element the lower the feed point impedance of the driven element. How do we match a 50-ohm coaxial line to a 5 to 15-ohm feed-point impedance? There are several possibilities. A 2, 3, or 4-wire folded dipole might be used as the driven element. A delta feed might be used on a dipole driven element, spreading out the feed lines to match proper impedance points. A half-delta-type of coupling called a gamma match (see **fig. 6**) may be used. In this system the braid of the coaxial cable is connected to the center of the driven element, which means that the unbalanced condition of a coaxial cable to an open-at-the-center dipole will not exist. The center conductor of such a 50-ohm cable is led out to the 50-ohm impedance point on the dipole, indicated by a minimum SWR shown on a reflectometer down at the transmitter output. To counteract the inductance of the center-conductor tap line, a small capacitor, C, should be added in series with the tap line to reduce the SWR still more. The more elements the beam has the further out the tap will have to be located.

An *entirely different* beam antenna is the driven type. Consider the two vertical $\lambda/4$ antennas being fed in phase (same length feed lines) in **fig. 7A**. Both antennas are emitting the same signal at the same time. The signal approaching you (out of the page) would be the in-phase sum of the two, or a maximum. Since the antennas are located $\lambda/2$ apart, when the signal from one reaches the other it will be 180° out of phase (180° = $\lambda/2$) with the signal being emitted by the second antenna at that instant, and there will be almost no signal transmission to the right or left along the plane of the page. The lobes transmitted, as seen from above the antennas (dots),

are shown dashed.

In **fig. 7B**, the two antennas are being driven 180° out of phase (one feed line is λ/2 longer than the other). As a result, the signals approaching you would be 180° out of phase and would cancel. You would receive essentially no signal from them. Maximum signals would now be transmitted in the line of the two antennas, or to right and left on the page, indicated by the dashed lobes shown above the antennas. Adding a third in-line driven element will narrow the radiated beamwidth and increase the signal strength in the maximum lobe direction. By using three or more driven elements and changing the phase of the signals fed to them, the maximum signal lobe can be directed in any desired direction (not a simple project).

If you pull a two-wire folded dipole apart in the middle to make a square loop out of it, **fig. 8**, a quad antenna is the result. The center impedance is no longer 300 ohms, but approaches 70 ohms allowing it to be fed with coaxial lines (preferably through a balun). If a second square loop is added (shown dashed) and spaced a λ/4 behind the driven quad element, a two-element parasitic beam is formed. Since the pick-up or capture area is larger than that of a two-element Yagi, the quad should have added gain. If the driven element is a quad and the reflector and directors are linear parasitic λ/2 elements, the beam is known as a quagi (quad and Yagi combination).

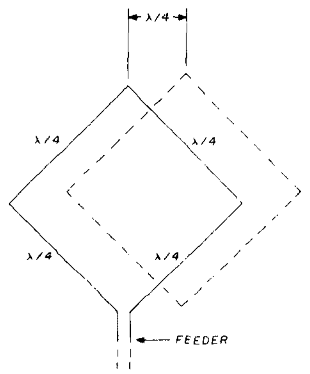


fig. 8. Quad, or four-sided radiating element. Possible reflector or director is shown dashed.

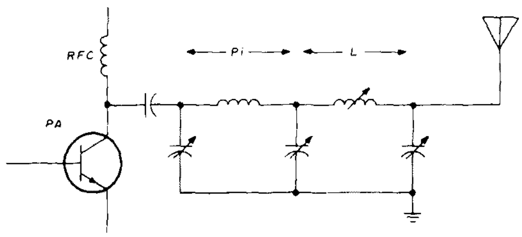


fig. 9. A Pi-L antenna tuning and Z-matching circuit.

matching networks

There are a variety of methods of coupling the final amplifier of a transmitter to the feeder of an antenna. We described a direct or capacitive coupled type, a link or inductive coupled type, and the basic pi-network which tends to attenuate harmonic output by the bypassing effect of the output capacitor if it is a large value. If a second section L and C is added to a simple pi-network, the harmonic attenuation will be better. This is known as a pi-L network, **fig. 9**. If the antenna is a random length it will exhibit either inductive or capacitive reactance to the L-network. By adjusting the C and L of these components the reactance can be tuned out to match a wide range of reactive or random length antennas to the PA stage.

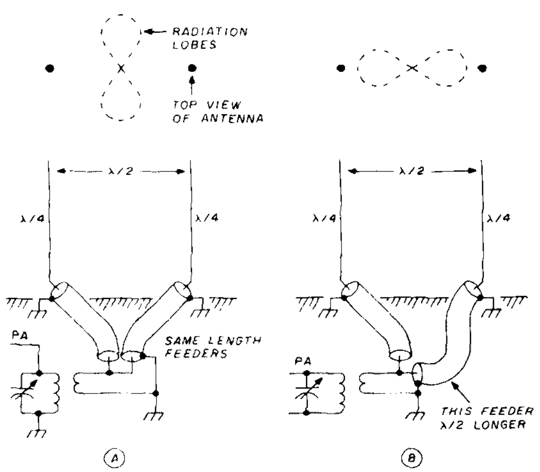


fig. 7. Two λ/4 verticals forming driven beams and means of switching lobe directions by using different lengths of feeders.

All tuning circuits between the PA active device and the antenna feeder are really some form of impedance matching circuit. They must make sure the impedance of the active device, through the tuned circuits, matches the feed line impedance to ensure maximum power into the feed line and then into the antenna. There are many different types of antenna tuners. They will usually produce an efficient coupling of the PA tuned circuit to whatever form of antenna feed is to be used: direct, high-impedance open-wire line, low-impedance open-wire line, or co-

axial line. They have the advantage of adding a tuned circuit to the antenna system, which can help attenuate harmonic output. One circuit that can be used as an antenna tuner is shown in **fig. 10**. To allow tuning to resonance on different Amateur bands, some of the turns of the antenna coil are shorted out (none are shorted for the 80-meter band, a few for the 40-meter band, more for the 20-meter band, and so forth).

A 600-ohm open-wire line would be connected across the low impedance (LOW Z line) contacts. The contacts are moved up or down the coil until a minimum SWR is indicated. Tuning C_1 to a still lower SWR will indicate resonance of the LC circuit. A 300-ohm or lower impedance parallel wire line would require tapping across fewer turns of the antenna coil. A coaxial feed line would be connected to the lower link coil to accept energy from the resonant LC circuit. The high impedance (HIGH Z line) points would be connected to feeders which are cut to a resonant length ($\lambda/4$, $\lambda/2$, etc.) to produce high impedance at the tuner end. If resonant feeders are a little too long they can be electrically shortened by varying the capacitance of C_2 and C_3. These two capacitors usually have shorting switches across them. All variable capacitors in this circuit are "hot" and must have insulated shafts between them and their dials or knobs.

When tuning a transmitter, you should not connect it to an antenna until you are at the point where you want to tune the antenna matching circuit. During preliminary tuning you should use a dummy load. This is usually a non-inductive wire resistor (50-72 ohms) immersed in transformer oil and in a metal can to prevent overheating of the wire. The metal can should be grounded to prevent signal radiation. Also, an open-wire transmission line of perhaps 300-ohm impedance and perhaps a $\lambda/2$ long, using iron resistance wire instead of copper, and connected at the far end to a 300-ohm resistor, will dissipate the rf energy as heat in the air but being a transmission line will radiate almost no signal. This is known as a losser line.

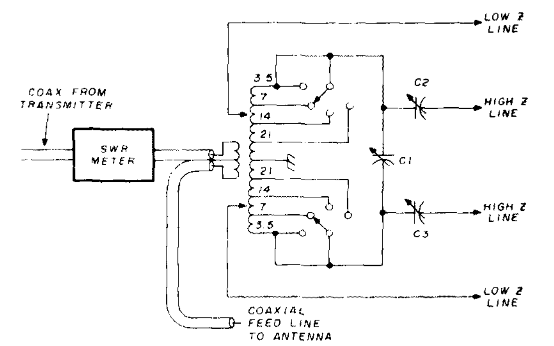


fig. 10. A possible four-band antenna tuner.

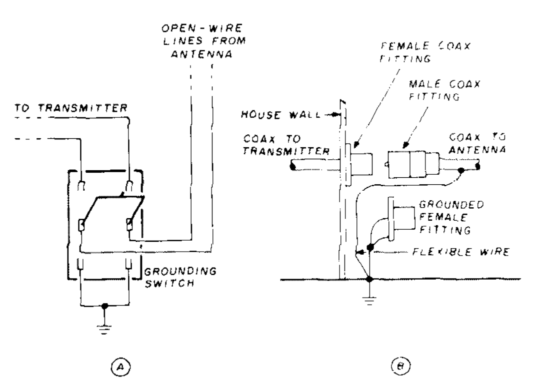


fig. 11. Protection from lightning (A) for open-wire lines, and (B) for coaxial cable transmission lines.

antenna safety tips

Antennas can have very high voltages and currents induced in them by lightning strikes that are as much as half a mile away. These can melt anything connected to the antenna. When there is lightning in the area, or if you can hear even distant thunder, ground your antenna! With open-wire feeders use a double-pole double-throw ceramic insulated high-current switch mounted on the outside of the building, **fig. 11A**. If you have a coaxial feeder, the male fitting on the feed line should be screwed into a female fitting mounted on the outside of the building that leads into the radio shack and to the transmitter. When lightning approaches, unscrew the male feeder and screw it into a dummy female fitting that is grounded, as in **fig. 11B**. Be sure you have a heavy flexible wire grounding your feeder fitting at all times. Do not get caught holding an ungrounded feed line while you are standing on the ground with lightning around!

When working on antennas be very careful about walking around with an aluminum ladder in your hands. If the ladder happens to touch an overhead power line, even if it is only 120 volts, you may put yourself between the ac hot line and ground. You will be electrocuted, and you won't be the first.

Do not climb wooden poles or metal masts without wearing an approved safety belt, and always check the condition of the belt. Make sure that feed lines are disconnected at the transmitter before you touch any antenna wires.

Be sure you use a good electrical ground on all your

equipment. A good ground can usually be achieved by driving an 8-foot (2.5-meter), 1-inch-diameter iron pipe into the ground. The pipe should be pounded closed at the bottom end and sharpened. Drill small holes in the pipe every foot or so. When the pipe is in the ground you can pour water into it each day. The water will leak out and keep the surrounding ground wet to improve ground conductivity. Two such ground rods are better than one.

If you erect metal masts for your antennas be sure they are anchored and guyed adequately. Your building inspector can tell you the requirement for erecting masts and towers in your city or county. Do not climb antenna poles, towers, or masts unless you are physically qualified to do it. Be very careful when adding metal sections on top of a base tower. Work on antennas on windless days. Remember, it is a lot more windy at the top of an antenna tower than on the ground.

Guy wires should come down to ground at an angle of about 45° for optimum strength, although on restricted-size lots the angle may have to be somewhat less. With guys at lesser angles, you may require more guy wires. Anchors for guy wires must be driven solidly into the ground for at least two feet, and preferably up to six feet for heavier poles or masts. Paint the bottom 7 feet (2 meters) of any guy wires you use with white paint, or hang white rags on them to reduce the danger of people running into them.

If your antenna is not in an area shaded to aircraft, if it is over 200 feet in height, or if it is within 5000 feet of a runway, you may have to paint it with orange and white stripes and install lights on top of it. If your antenna does not exceed nearby buildings, trees, and so on by more than 20 feet (7 meters) or so, you should never have to notify the Federal Aviation Administration (FAA) of its existence. For precise legal information on antenna installations, see the FCC Rules and Regulations, Volume I, Section 17.

height above average terrain

The effective height of an antenna is the height of its center above average terrain. Average terrain can be determined from a contour map of your area. Locate your antenna position on the map or chart. Draw eight radials 45° apart starting with the first one northward. Extend each line for a distance of 10 miles. Determine the elevations above mean sea level (AMSL) of the base of your antenna and all points 2, 4, 6, 8, and 10 miles out on each radial. Add all the AMSL values and divide by the number of points used. This will be the effective elevation of the average terrain at the base of your antenna. Such information is only required for large antenna tower installations and is rarely used by most Amateurs.

FCC test topics

The following Novice class FCC test topics are discussed in this article, but should be understood by Technician/General, Advanced, and Extra class license applicants also:

- Parallel conductor feed lines
- Coaxial cable feed lines
- Ground systems
- Lightning protection for antenna systems
- Antenna installation safety

The following Technician/General class FCC test topics are discussed in this article, but should be understood by Advanced and Extra class license applicants also:

- Antenna orientation
- Balanced, unbalanced feed lines
- Characteristic impedance of antennas
- Antenna-feed line mismatch
- Significance of standing-wave ratio
- Physical dimensions of antennas
- Use of a reflectometer (VSWR meter)
- Antenna bandwidth
- Yagi antenna
- Radiation patterns, directivity, major lobes
- Quad antenna
- Use of antenna tuning or matching networks
- Use of non-radiating load or dummy antenna

The following Advanced class FCC test topics are discussed in this article, but should be understood by Extra class license applicants also:

- Electrical length of feed lines
- Folded, multiple wire dipoles
- Radiation resistance
- Mobile antennas
- Loading coils, base, center, top
- Trap antennas
- Parasitic elements
- Antenna gain, beamwidth
- Driven elements
- Impedance matching networks; Pi, L, Pi-L
- Height limitations for antennas, including FAA notification criteria, and calculation of height above average terrain.

For additional information on these subjects, you can refer to *Electronic Communication*, or to *Amateur Radio Theory and Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through *ham radio*'s Bookstore.

ham radio

the weekender

a single-chip keyer for QRP

The keyer described in this article was designed to be built into a Heath HW-8 transceiver. However, it should function equally well with most QRP rigs. The keyer is designed around the Curtis 8044 CMOS keyer integrated circuit. Since the HW-8 has sidetone, that function was omitted from the keyer.

Without sidetone, the keyer chip required so little power the only problem was ensuring the proper operating voltage for the IC without consuming more power in the regulator than in the rest of the keyer. The solution was the circuit consisting of D_1, D_2, R_1, and R_7. Power (9-14 Vdc) is supplied through a 5.1 volt zener (D_1) in order to limit the IC voltage from 4 to 9 Vdc. Resistor R_1 (47 K) ensures that sufficient current is drawn through D_1 to keep it functioning properly. The 9.1 volt zener (D_2) and 100-ohm resistor (R_7) protect the IC should the input exceed 14 Vdc.

R_2, C_2, R_3 and C_3 protect against false operation from key contact bounce. The combination of C_4, R_6 and the external 500K speed-control potentiometer provide proper timing for the selected speed. Diodes D_3 through D_8 protect the IC from rf or noise spikes on the input lines. Transistor Q_1 keys the CW transmitter. Your transmitter key line should not exceed a positive 50 Vdc key-up or 50 mA key-down, or the transistor (and possibly the IC) may be destroyed.

The keyer paddle will normally be connected to the ground, dot and dash inputs. If bug type operation (manual dashes and automatic dots) is desired, the paddle dash contact may be connected to the bug input instead. A manual key or tune switch may be connected between ground and the bug input.

Installation was simple. The keyer was mounted on the side panel with spacers, similar to the way Heath mounted the audio amplifier board. The speed potentiometer was fitted with a concentric shaft and SPDT switch. This assembly was mounted in place of the original narrow-wide switch. The new SPDT switch was wired to control the narrow-wide function while the potentiometer served as the keyer speed control. An extra HW-8 concentric knob set (for the rf and af controls) was ordered from Heath and used on the new controls. A 4-pin Amphenol 126 series *miniature hexagonal* socket was mounted in place of the key jack in order to provide the paddle connections. The Amphenol connector takes the same size mounting hole as the original key Jack.

By Robert W. Lewis, W3HVK, P. O. Box 41, Stevensville, Maryland 21666

keyer operation

If you haven't tried for many years to operate a

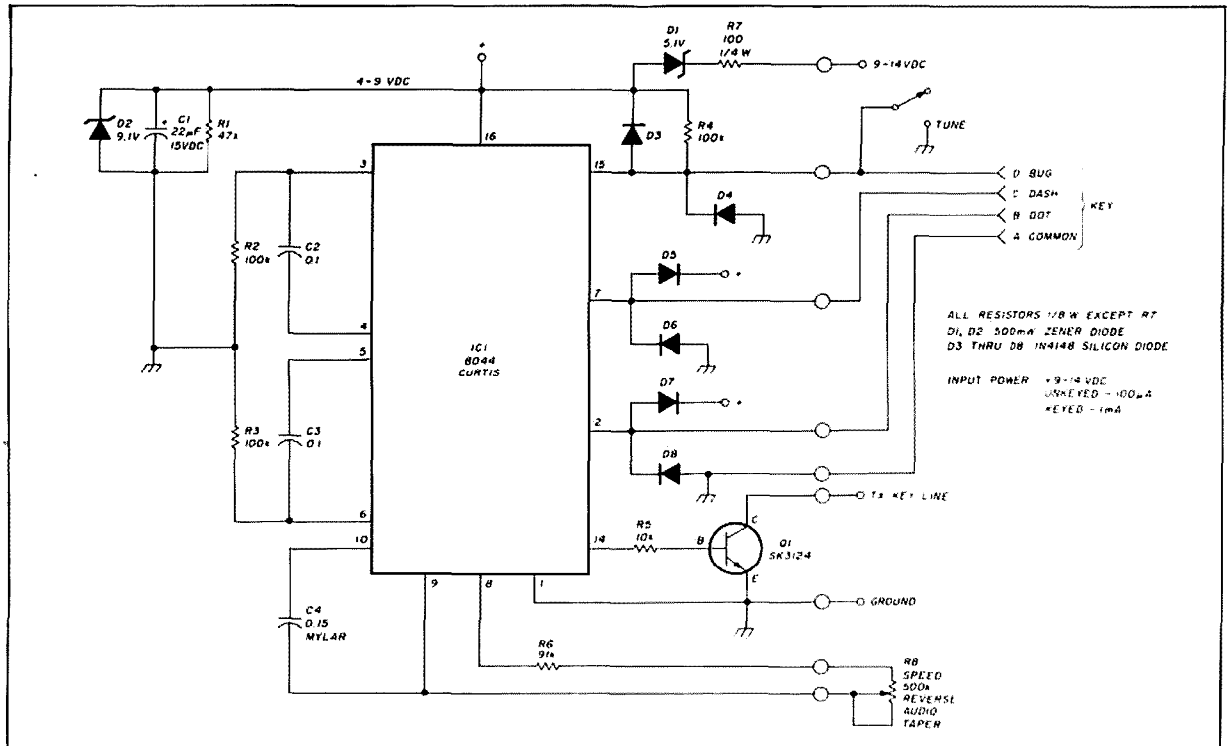


fig. 1. QRP keyer schematic.

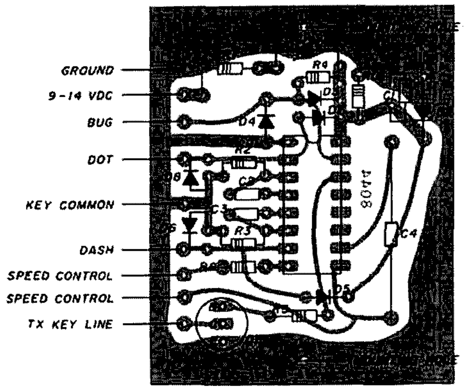


fig. 2. QRP keyer component layout (component side view).

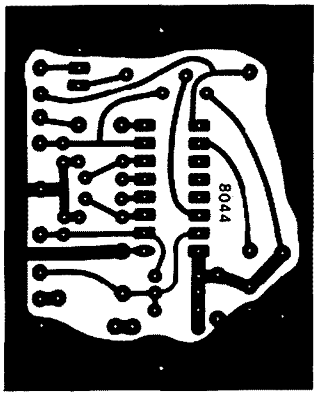


fig. 3. QRP circuit board negative (actual size, foil side view).

keyer, give one of the newer models a chance. My old tube-type keyer sat in the corner for years because I never could get accustomed to it. Adjusting to the new keyer with its self-completing function and dot/dash memories was a breeze. While the keyer will function with an older paddle or in the bug mode, I highly recommend an investment in an iambic paddle. Iambic or squeeze keying greatly simplifies sending letters C,F,K,L,Q,R,Y and the period. After an hour or so with a code practice oscillator, squeeze keying should become as natural as your old straight key.

ham radio

note

IC_1 is an 8044, and is available from Curtis Electro Devices, Inc., Box 4090, Mountain View, California 94040.

HAM CALENDAR October

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY

W1AW Schedule

April 25-October 24, 1982 — MTWThFSSn = Days of Week — Dy = Daily

W1AW code practice and bulletin transmissions are sent on the following schedule:

EDT	Slow Code Practice	MWF 9 A.M., 7 P.M.; TThSSn 4 P.M., 10 P.M.
	Fast Code Practice	MWF 4 P.M., 10 P.M.; TTh 9 A.M.; TThSSn 7 P.M.
	CW Bulletins	Dy 5 P.M., 8 P.M., 11 P.M.; MTWThF 10 A.M.
	RTTY Bulletins	Dy 6 P.M., 9 P.M., 12 P.M.; MTWThF 11 A.M.
	Voice Bulletins	Dy 9:30 P.M., 12:30 A.M.
CDT	Slow Code Practice	MWF 8 A.M., 6 P.M.; TThSSn 3 P.M., 9 P.M.
	Fast Code Practice	MWF 3 P.M., 9 P.M.; TTh 8 A.M.; TThSSn 6 P.M.
	CW Bulletins	Dy 4 P.M., 7 P.M., 10 P.M.; MTWThF 9 A.M.
	RTTY Bulletins	Dy 5 P.M., 8 P.M., 11 P.M.; MTWThF 10 A.M.
	Voice Bulletins	Dy 8:30 P.M., 11:30 P.M.
PDT	Slow Code Practice	MWF 6 A.M., 4 P.M.; TThSSn 1 P.M., 7 P.M.
	Fast Code Practice	MWF 1 P.M., 7 P.M.; TTh 6 A.M.; TThSSn 4 P.M.
	CW Bulletins	Dy 2 P.M., 5 P.M., 8 P.M.; MTWThF 7 A.M.
	RTTY Bulletins	Dy 3 P.M., 6 P.M., 9 P.M.; MTWThF 8 A.M.
	Voice Bulletins	Dy 6:30 P.M., 9:30 P.M.

1 (Fri)

1982 ARRL WEST GULF DIVISION CONVENTION & HOUSTON COM VENTION — Held at the Astro Village Hotel complex in Houston. For more info contact: Houston Com Vention 82, P.O. Box 79252, Houston, TX 77279, (713) 481-4586. 1-3

2 (Saturday)

PACK RATS SIXTH ANNUAL MID-ATLANTIC VHF CONFERENCE & HAMARAMA — Held in Warrington, PA. For information: HAMARAMA 82, P.O. Box 311, Southampton, PA 18966 or Lee Cohen, K3MXM. 2-3

NEW ENGLAND DIVISION CONVENTION — Held at the Sheraton Boxboro Hotel in Boxboro, MA. For more info, contact W1THT. 2-3

RAGS ANNUAL HAMFEST — Held at New York State Fairgrounds in Syracuse. Flea market space available. Talk in on 90/30 and 31/91. 2

VK-ZL-OCEANIA PHONE CONTEST 2-3

CALIFORNIA QSO PARTY 2-3

3 (Sunday)

YONKERS ELECTRONICS FAIR & GIANT FLEA MARKET — Held in the Yonkers Municipal Parking Garage. For more info: Yonkers ARC, 53 Hayward St., Yonkers, NY 10704. 3

RA COM '82 — Sponsored by the Mt. Prospect ARC & Cook County ALERT. Held at Mt. Prospect High School, Mt. Prospect, IL. For info: RA COM '82, P.O. Box 99, Mt. Prospect, IL 60056. 3

1982 ROME HAMFEST — Rome Civic Center, Rome, GA. For more info contact Buddy Wake, NG4D, 18 London Lane SE, Rome, GA 30161. 3

31ST ANNUAL ROCK HILL HAMFEST — Held in Rock Hill, SC. For more info: YCARS, Box 4141 CRS, Rock Hill, SC 29730. 3

4 (Mon)

WEST COAST BULLETIN — 9PM PDT (8PM PST) 0400 UTC 3540 KCS A-1 22wpm. 4

5 (Tues)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

6 (Wed)

7 (Thur)

8 (Fri)

ELECTRONICA — First annual public electronics show held at the Hynes Auditorium in Boston, MA. Ham radio, computers, security systems and more. 8-11

ARRL PACIFIC DIVISION CONVENTION — Sponsored by the Santa Cruz County ARC to be held at the Holiday Inn in Santa Cruz, CA. For more info: SCCARC Convention, P.O. Box 238, Santa Cruz, CA 95061. 8-10

9 (Saturday)

40TH ANNIVERSARY OF THE FIRST CONTROLLED NUCLEAR EXPERIMENT — *Sponsored by the Argonne Amateur Radio Club.* 9-10*

WESTERN CAROLINA ARC SEVENTH ANNUAL AUTUMNFEST — Held at the Asheville Civic Center in Asheville, NC. For info: WCARS, P.O. Box 1488, Asheville, NC 28802. 9

ARRL VIRGINIA STATE CONVENTION & TIDEWATER COMPUTER SHOW — Held at the Virginia Beach Pavilion. For more info contact N4NV. 9-10

MEMPHIS HAMFEST — Held at the Memphis Fairgrounds. For more info contact Clayton Elam, K4FJZ. 9-10

COOSA VALLEY ARC HERITAGE DAYS — From 1200Z October 9 to 2200Z October 17. 9-17*

VK-ZL OCEANIA CW CONTEST 9-10

10 (Sunday)

KETTLE MORAINE RAC ANNUAL HAM, COMPUTER & VIDEO FEST — Held at the Waukesha County Expo Center, Waukesha, WI. For more info: KMRA Club, P.O. Box 411, Waukesha, WI 53187. 10

HOOSIER HILLS HAM CLUB'S 21ST ANNUAL HAMFEST — Held at the Lawrence County 4-H Fairgrounds, US 50, Bedford, IN. For more info contact Dick Reistter, KA9JTZ. 10

COLUMBIA ARA 6TH ANNUAL HAMFEST — Held at the Howard County Fairgrounds in Maryland. For more info: Sue Crawford, 5881 Mink Hollow Rd., Highland, MD 20777. 10

11 (Mon)

12 (Tues)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

COLQUITT COUNTY HAM RADIO SOCIETY — [illegible] station from the 5th annual Sunbelt Agricultural Exposition. 12-14*

13 (Wed)

14 (Thur)

15 (Fri)

16 (Saturday)

NEW ORLEANS HAMFEST-COMPUTERFEST — Amacom 82 to be held at Delgado Community College near City Park. For more info contact Amacom chairman, WA5MJM. 16-17

IRWIN AREA ARA SWAP & SHOP — To be held at the Circleville VFD in Irwin, PA. For more info write WB3EKB or call 412-863-8397. 16

PENNSYLVANIA QSO PARTY 16-17

BOY SCOUTS JAMBOREE 16-17

ARCI QRP CW CONTEST 16-17

17 (Sunday)

CHICAGO CITIZEN'S RADIO LEAGUE 1ST ANNUAL HAMFEST — For more info: Fred Marlette, KA9FUD. 17

19.79 REPEATER ASSOCIATION OF CHELSEA FIRST ANNUAL FLEA MARKET — Held at the Beachmont VFW Post in Revere, MA. 17*

RSGB 21 MHz CW CONTEST 17

18 (Mon)

WEST COAST BULLETIN — 9PM PDT (8PM PST) 0400 UTC 3540 KCS A-1 22wpm. 18

19 (Tues)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

20 (Wed)

21 (Thur)

22 (Fri)

23 (Saturday)

MARYLAND-DISTRICT OF COLUMBIA QSO PARTY — Sponsored by the Columbia ARA from 1800Z October 23 to 2100Z October 24. 23-24*

HAMFEST CHATTANOOGA 1982 & TENNESSEE STATE ARRL CONVENTION — Held at the Chattanooga State Technical Community College. Contact N4ECA or KA4BNY. 23-24

24 (Sunday)

SPECIAL EVENTS STATION — Sponsored by Holmesburg ARC and University of Pennsylvania. 24-25*

25 (Mon)

26 (Tues)

AMSAT East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning)

AMSAT Mid Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning)

AMSAT West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning)

27 (Wed)

28 (Thur)

29 (Fri)

30 (Saturday)

31 (Sunday)

HAM DXPEDITION AT SEA — Sponsored by the Penn Wireless Association aboard the Royal Caribbean Line's Sun Viking. For more info contact Bill Buckley, W2ALG, 1156 Oxford Valley Rd., Levittown, PA 19057. 31-10

MARION ARC 8TH ANNUAL HEART OF OHIO HAM FIESTA — Held at the Marion County Fairgrounds Coliseum. For info: W8CAY. 31

FRAMINGHAM ARA 7TH ANNUAL FLEA MARKET — Held at the Framingham Civic League Building. Contact Ron Ezaka, 3 Dusick Rd., Framingham, MA 01701 for more info. 31

***SEE COMING EVENTS**

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box R802, Council Bluffs, Iowa 51502.

SATELLITE TELEVISION — Howard/Coleman boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

BUILD YOUR OWN Satellite TV low noise amplifier and Save! New, fully illustrated step-by-step instruction Manual $10.00. Satisfaction guaranteed. XANDI, Dept. 23A, Box 25647, Tempe, AZ 85282.

SATELLITE TELEVISION: Discount prices on all major TVRO items. Communications Consultants. (501) 452-3149.

NEVADA: "Silver State Callbook." First edition includes every Nevada amateur, repeater and more. If you need Nevada, you need this Callbook. Only $3.00 ppd. Wide Area Data Group, P.O. Box 3132, Sparks, NV (702) 358-6303.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH, (408) 292-6000.

HOMEBREW QUAD for under $70. See how easy quad building can be. Send for brochure to WBØVVF, 2629 N. Elsie, Davenport, Iowa 52804.

COLLECTORS: HRO-5RA1, w/speaker, w/orig. manual. Best offer. K2LM, L. Reeves, RD3, Glens Falls, NY 12801. (518) 792-5533.

DX PREDICTOR: Computes MUF, FOT, LUF between any two OTHs. Documented: Easy to Use: Graphical/tabular output. Adapted from algorithms currently used by US Govt. agencies. Available for Apple II + (48K; disk or cassette) and PET (16K, cassette only). Documentation $5 (refundable). Program + Documentation $40.00. Checks to K.J. Flynn, P.O. Box 903, Mountain View, CA 94042.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

$169 buys more when it's "TAIMD," The Adaptive International Morse Decoder. No adjustments! Assembled, tested, proven. Telecraft Laboratories, Box 1185, E. Dennis, MA 02641.

HAM-AD-FEST™ — Next 6 issues, $2.00. WA4OSR, Box 973, Mobile, AL 36601.

D & V RADIO PARTS — Variable capacitors, miniductors, toroids, etc. Write for flyer, stamp please. 12805 W. Sarle, Freeland, Michigan 48623.

MOBILE IGNITION SHIELDING provides more range with no noise. Available most engines. Many other suppression accessories. Literature, Estes Engineering, 930 Marine Dr., Port Angeles, WA 98362.

HANDIE-TALKIE OWNERS, take note! Now you can operate your HT from your car, and even charge the ni-cads (on certain models) with the new Mobile Energizer for only $21.95, PPD! Order now, or write for details. Contemporary Electronic Products, P.O. Box 570549, Miami, FL 33157.

SAFETY BELTS. $35.00 and up. Free information. Avatar Co., (W9JVF) 1147 - (H) N. Emerson, Indianapolis, IN 46219.

CONTESTERS: Package of programs designed for the ARRL DX, COWW, CQWPX and IARU Radio Sport Contests produces scored, duped log, dupe sheet, OSLs and many valuable operator statistics. TRS-80 Model 1, 48k, 1 or more discs, MX-80 printer required. $69.95 plus tax non-refundable. Sample printout with SASE. P. Chamalian, W1RM, P.O. Box 1188, Burlington, CT 06013.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Williams, PO #7057, Norfolk, VA 23509.

VERY In-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/FM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

AFC SEMI-KITS! Stop VFO drift. See June 1979 HR. $55.00 plus $3.00 UPS. Mical Devices, P.O. Box 343, Vista, CA 92083.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

Coming Events

ACTIVITIES

"Places to go..."

GEORGIA: The 1982 Rome Hamfest, Sunday, October 3 at the New Location — Rome Civic Center, Turner McCall Blvd., Rome, 9 AM to 4 PM. Admission for hams will be a door prize ticket. Ladies' prizes. Enjoy the barbecue, fun and fellowship. Talk in on 147.90-30 repeater. Contact Buddy Waller, NO4U, 18 London Lane SE, Rome, GA 30161.

ILLINOIS: The Chicago Citizens Radio League's first annual Hamfest, October 17, 7 AM to 4 PM, North Shore American Legion Post, 6040 N. Clark. For table reservations: Fred Martette, KA9FUO, 1851 W. Chase, Chicago, IL 60626.

INDIANA: The 10th annual Fort Wayne Hamfest, sponsored by the Allen County Amateur Radio Technical Society, November 14, Allen County Memorial Coliseum. Admission: $3.00 door; $2.50 advance; children under 11 free. Regular tables $6.00. Premium tables $20.00. $1.00 parking. Doors open 8 AM. For tickets or table information: Becky Skinner, KA9GWE, 9720 Pinto Lane, Fort Wayne, IN 46804.

INDIANA: The Hoosier Hills Ham Club's 21st annual Hamfest, Sunday, October 10, Lawrence County 4-H Fairgrounds, U.S. 50, Bedford. Registration $3.00 per person, swap shop $2.00, bring own tables. Talk in on 146.13-73 at 3910 kHz. Free fish fry, campfire, entertainment, coffee and overnite camping Saturday night, October 9. Gate open 10 AM Saturday for campers and flea market setup. Registration prizes, ladies' free bingo. Raffle prize: Hitachi Video Tape System. For information: Dick Reisiter, KA9JTZ, Secretary, Hoosier Hills Ham Club, Box 891, Bedford, IN 47421.

LOUISIANA: Amacom '82, the New Orleans Hamfest-Computerfest, October 16 and 17, Delgado Community College near City Park. The new location means more space for meetings, tech forums, exhibitors, flea market and convenience to New Orleans' attractions. Admission $3.00 per person over 12 years. Forums on DXing, color SSTV and computering, ladies' activities and prizes. FCC exams Saturday morning. Radio Amateurs may use the club's repeaters, W5GAD/R, 147.285-.885 MHz, linked with 449.0-444.0 MHz for directions and Amacom information. For reservations for FCC tests and other information: W.D. Bushnell, WA5MJM, Amacom chairman, c/o Jefferson Amateur Radio Club, P.O. Box 73665, Metairie, LA 70033. (504) 887-5022.

MASSACHUSETTS: The 19-79 Repeater Association of Chelsea will hold its annual Flea Market, Sunday, October 17, 11 AM to 4 PM. (Sellers admitted at 10AM). Beachmont VFW Post, 150 Bennington St., Revere. Admission $1.00. Sellers tables $6.00 advance; $8.00 at door if available. Talk in on 19079 and 52 direct. For table reservations send check to: 19-79 Repeater Assoc., P.O. Box 171, Chelsea, MA 02150.

MASSACHUSETTS: The Framingham Amateur Radio Association's 7th annual flea market, the largest indoor ham flea market in New England, Sunday, October 31. New location: Framingham Civic League Building, 214 Concord St., downtown Framingham (diagonally across from previous location). Doors open 10 AM. Sellers set-up starts 8:30 AM. Admission $2.00; tables $10.00. Radio equipment, computer gear, bargains galore. Talk in on 75/15 and 52 direct. For table reservations: Ron Egalka, K1YHM, 3 Driscoll Dr., Framingham, MA 01701.

NORTH CAROLINA: The Cabarrus Amateur Radio Society's annual Hamfest, November 7, 9 AM to 5 PM, Concord Boy's Club, Spring Street, Concord. Admission $2.50 advance; $3.00 door. Prize drawing for advance tickets plus main prize drawing and hourly prizes. Flea market tables $4.00 or table space $2.50. Speakers, forums, ladies' bingo, refreshments, free parking. Talk in on 146.655. For advance tickets, flea market tables or space send check to: C.A.R.S., P.O. Box 1290, Concord, NC 28025.

OHIO: The Marion Amateur Radio Club's 8th annual Heart of Ohio Ham Fiesta, Sunday, October 31, 0800 to 1600 hours, Marion County Fairgrounds Coliseum. Tickets $3.00 advance, $4.00 door. Tables $5.00. Door prizes, XYL prizes, check-in prize. Food. Check-in on 146.52, 147.90/30, 223.34/224.94. For information, tickets or tables: Paul Kilzer, W8GAX, 393 Pole Lane Road, Marion, OH 43302.

PENNSYLVANIA: The R.F. Hill ARC's 6th annual Hamfest, November 7, Sellersville National Guard Armory, Sellersville. Doors open 7 AM for sellers; 8 AM for buyers. Prizes, refreshments. Talk in on 28/88 and 52. For information: R.F. Hill ARC, Box 29, Colmar, PA 18915.

TENNESSEE: The Memphis Hamfest, the last big one of the season, Saturday, October 9, 8 AM to 4 PM, and Sunday, October 10, 8 AM to 2 PM, Memphis Fairgrounds, Mid South Building. Children under 14 free. Radio and Computer forums, ladies' programs, hospitality party Saturday night. On site trailer hookups. Talk in on 28/88 and 25/85. For information: Clayton Elam, K4FZJ, 28 N. Cooper, Memphis, TN 38104. (901) 274-4418 days. (901) 743-6714 evenings.

TENNESSEE: Hamfest Chattanooga 1982 and the Tennessee State ARRL Convention, October 23 and 24, Chattanooga State Technical Community College, Amnicola Highway, Chattanooga. Free admission. Door prize tickets sold for hourly and main prizes. Indoor/outdoor flea markets, forums, ladies' and children's activities, refreshments available, hospitality party and Wouff Hong Ceremony. Nearby motels and camping areas. For dealer information: Hamfest Chattanooga, P.O. Box 3377, Chattanooga, TN 37404 or Maxine Barrett, N4ECA, (404) 398-3358. For indoor Flea Market spaces: Dave Roberts, KA4BNY, (615) 899-9043. Talk in on 146.19/79.

TEXAS: The 1982 ARRL West Gulf Division Convention and Houston Com-Vention, October 1-3, Astro Village Hotel complex located next to the Astrodome and Astroworld, 2350 South Loop (I-610) at Kirby Drive exit. Talk in on 147.69/.09 and 222.66/224.26. Air-conditioned exhibit area, covered flea market, prizes, transmitter hunt, homebrew competition, Saturday night banquet, Tony England, WØORE speaker, Woufl Hong ceremony and NASA-JSC tour, seminars, forums, family activities for non-amateurs. Advance registration \$5.00; door \$7.00. Covered flea market spaces \$10.00 both days (includes table and one chair). For information and registration: Houston-Com-Vention 82, P.O. Box 79252, Houston, TX 77279. (713) 481-4586.

OPERATING EVENTS

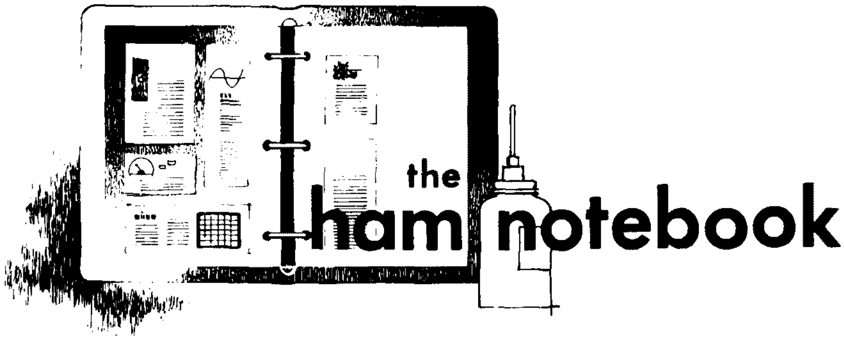
"Things to do..."

OCTOBER 9 AND 10: The Argonne Amateur Radio Club plans to operate memorial station, W9QVE to commemorate the 40th anniversary of the first controlled nuclear chain reaction experiment which was conducted at the Alonzo Stagg field, University of Chicago campus. Two stations will operate from 1500 GMT, October 9 through 2300 GMT, October 10. Frequencies: SSB — 3985, 7285, 14285, 21285, 28585. CW — 3545, 7045, 14045, 21045, 28045, 3765, 7165, 21165 Novice bands. RTTY: 14090 and 146.70 MHz. 2M: 145.19/144.59 Rptr, 146.52 and 147.42 simplex. Send business SASE or \$1.00 for an 8X11 unfolded certificate to: AARC, P.O. Box 275, Argonne, IL 60439.

OCTOBER 23 AND 24: Maryland-District of Columbia QSO Party sponsored by the Columbia Amateur Radio Association from 1800Z October 23 to 2100Z October 24. Exchange QSO number, RS(T) and state/province/country, county for MD stations. Suggested frequencies: Phone — 3950, 7250, 14,290, 21,390, 28,590. CW — 60 kHz from low end; Novice — 3720, 7120, 21,120, 28,120. Certificates for top scores in each category awarded. Mail logs, dupe sheets, summary by November 30 to CARA, Inc., c/o Robert K. Nauman, WA3VUO, 4017 Font Hill Drive, Ellicott City, MD 21043.

OCTOBER 24 AND 25: Special events station, W3WP, the Holmesburg Amateur Radio Clubs and the University of Pennsylvania will operate W3WP for 24 hours from Penn's Landing, Philadelphia to celebrate the birthday of the City's founder, William Penn. This event is an official part of the year long celebration observing the city's 300th birthday. Exchange: RS(T), city, state, country and W3WP log number. Frequencies: Phone — 3.925, 7.257, 14.290, 21.365, 28.550 ± QRM. Also Holmesburg/U of P Repeater, 2 m, 146.685. CW: high end of each CW band. A handsome commemorative QSL card will be sent to all stations contacting W3WP. SASE to: Harry White, N3HW, QSL Manager, 7520 Verree Road, Philadelphia, PA 19111.

NOVEMBER 13 AND 14: The 50th anniversary of the Sandusky (Ohio) Radio Experimental League will be celebrated with a QSO party. Amateurs worldwide are invited to participate. Club members will operate on live Amateur bands using the club call W8LBZ. Times: 1800 UTC Saturday, November 13 until 1800 UTC Sunday, November 14. Frequencies: Novice — 28150 and 7125; CW 3740, 7040, 14040, 21040 and 28040. Phone 3910, 7265, 14280, 21360 and 28600. All ± 10 kcs. For a special QSL card/certificate send your QSL card to: QSL Manager, W8LBZ, 2909 West Perkins Avenue, Sandusky, Ohio 44870.



the ham notebook

updating your CW station

Owners of older CW equipment, like me, find many advantages to having such gear, not the least of which is low cost and ease of repair. These rigs, however, often lack features which are almost essential for the avid CW operator. Many models lack a sidetone, and some have no internal relay for switching from transmit to receive.

My HF station consists of a Drake R-4 and a Heathkit DX-60A. The DX-60A provides a switched voltage on the accessory socket for an external relay, but I wanted full break-in. So I built a solid state T-R switch I saw in a *ham radio* article ("Solid State T-R Switch for Tube Transmitters," by Malcolm Crawford, K1MC, *ham radio*, June, 1980, pages 58-61). It worked like a charm, but I still did not have a sidetone, and, even with a sidetone, I had no way to mute the receiver. Thus was born this circuit.

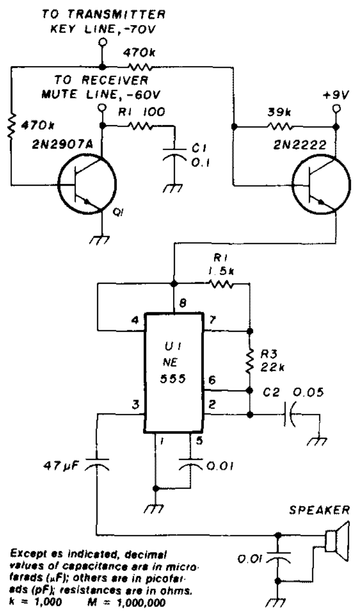


fig. 1. Schematic diagram for the mute-sidetone circuit.

This circuit does two things: It provides a pleasant sidetone and it mutes the receiver on every dot and dash.

The Drake R-4 has a mute line voltage of − 60 volts and the DX-60A has a key line voltage of − 70 volts. I am sure that this circuit could be used with a number of tube-type transmitter/receiver combinations.

The key-line voltage is used to turn two transistors on and off. Q1 is a PNP type, rated for at least 60 volts. A 2N2907A fits the bill perfectly. When the key is up, the negative voltage on the base of Q1 turns the transistor on, grounding the mute line and unmuting the receiver. When the key is down, the base of Q1 goes to ground and the transistor shuts off, opening the mute line and muting the receiver. R1 and C1 keep the receiver muted for a brief moment on key-up. These values may need to be changed, depending upon the keying characteristics of the transmitter.

Q2 in an NPN type. The +9 volt supply need not be regulated; a 9-volt battery would work fine. On key-up, the transistor is off. On key down, the +9 volts turns on the transistor, which turns on the sidetone provided by U1, an NE555 timer. The output of U1 is fed into a small 2-inch speaker. The pitch of the sidetone is determined by R2, R3, and C2, according to this formula:

$$frequency = 1.46/[(R2 + 2 \cdot R3)\,C2]$$

The 0.01-mF capacitor across the speaker leads will minimize rf feedback into the IC.

The entire circuit can be mounted underneath the chassis, or at any other convenient location. I mounted mine in a small box which sits loosely on top of the transmitter chassis. The box has four jacks, one for the mute line, one for the key line, one for the 9-volt power supply, and one for the speaker.

This addition to your CW station, along with an electronic T-R switch, will make your operating a real pleasure.

Dan Sanderson, KM5T

more notes on the 5CX1500A power pentode

In my earlier article, "Notes on the EIMAC 5CX1500A Power Pentode" (*ham radio*, August, 1980, page 61), I made the statement that EIMAC had changed the outer plating of the tube to nickel for reasons of cost, adding: "There is no noticeable electrical effect on the tube."

Subsequent experience has not only shown that this is *not* the case, but also that the effect is a deleterious one to both the tube and its socket if the tube and amplifier are used heavily.

The IR losses in nickel are considerably higher than those of silver or its various compounds — so much so that, in the case of the 5CX1500, the resultant heating of the various electrode rings can be enough to destroy both the rings and the surrounding socket material.

This situation was brought to EIMAC's attention late in 1980, and they subsequently returned to silver-plating all exposed metal on the

5CX1500A. Although many broadcast users of the tube were notified of this situation, it is likely, however, that some nickel-plated 5CX1500A's may still be in operation in the Amateur service, particularly some sold by broadcasters to Amateurs. The purpose of this note is to alert the Amateur community, so that users of such tubes may decide whether to continue using the nickel-plated 5CX1500A in their rigs.

Arthur Reis, K9XI

measuring coax with an RCL bridge

Not long ago I came across a bargain that was too good to be true: used coax for only 1 cent per foot. The person selling it explained that it had been used only once and admitted he didn't know exactly how long it was. After we estimated the length, I paid for what I thought was 165 feet of RG-58.

I wasn't about to unroll all that coax (besides, my tape measure was broken) to measure it the old-fashioned way. Instead, I decided to use my RCL bridge to measure the total capacitance of the coax and then calculate the length based on the capacitance per foot. At first that might seem like technological overkill, but there are times when it isn't convenient to physically measure coax length. For example, if coax is buried or installed in some inaccessible location, it might not be practical to measure its length by conventional means.

The procedure consists of four simple steps. First, check the coax for continuity; second, check the coax for shorts; third, measure the capacitance of the cable; and fourth, calculate the length of the cable. To check the continuity of the coax, put a temporary short across one end of the cable and connect the RCL bridge to the other end. With the bridge set to measure low values of resistance, you should get an indication of low resistance. High resistance is evidence of some physical damage to the coax. With this simple continuity test, we aren't measuring the impedance of the coax; we're just checking for breaks in the cable. Next, with the bridge still connected, remove the temporary short from the end of the cable. The bridge should now give an indication of infinite resistance. A low resistance would mean there was a short in the coax, and a measurable resistance would point to leakage through the dielectric between the shield and the center conductor.

When you are sure the coax has continuity but no shorts or leakage, switch the bridge to measure capacitance and measure the total capacitance. Keep the leads from the bridge to the cable as short as possible to minimize stray capacitance. The length of the coax can be calculated from this equation:

$$length\ in\ feet = \frac{total\ capacitance}{capacitance\ per\ foot}$$

When using this method to measure the length of coax, the most important thing to know is the capacitance per foot of the coax being measured. When you consult a catalog or specification sheet to find out the capacitance of a particular type of coax, make sure it is for the exact coax you are measuring. Remember, if RG-59 from the XYZ cable corporation is rated at 17 pF per foot, there's no guarantee that RG-59 from the ABC wire company is also 17 pF per foot.

John W. Frank, WB9TQG

3-500Z tube failure

One of the most common of amplifier troubles is grid to filament short-circuits in 3-500Z. Almost every brand of 3-500Z amplifier occasionally suffers from this problem. The popular notion is that the tube shorted, which almost seems logical if the tube reads zero ohms with an ohm-meter. But such a conclusion may be putting the cart before the horse.

My own SB-220 amplifier had a persistent problem of arcing the plate-tuning capacitor — but only on the 40-meter band and never on 80 meters, the only other band I use the amplifier for. Another gremlin on 40 meters was that one plate-parasitic choke would sometimes get hot and make a burning smell. Why only on 40 meters?

One day a friend offered me a new set of 3-400Z tubes at a bargain price. The 3-400Z is very similar to the 3-500Zs, except for a higher amplification factor and lower plate dissipation rating. Since a higher amplification factor usually means less bias requirement, I shorted out the Zener bias-diode and fired up on 80 meters. The power gain was slightly better than the original tubes — great. I used the new tubes for several hours and went to bed thinking I had a pair of winners. The next day I loaded up on 40 meters and the amplifier made a loud noise followed by an evil smell. I shut the amplifier off and removed the line-plug from the outlet. As I removed the case, small pieces of crispy-crittered component fell on the table. I felt sick. Looking inside, I found the 1-mH grid-to-ground choke had burned open, and the individual sections of the windings had collapsed on themselves. One of the three grid-to-ground capacitors had vanished. Since this capacitor was rated at 500 working volts, there must have been at least triple the 500 volts to make it vanish so completely. The fusing current for the wire used in the burned choke must have been at least 2 amperes. A little calculating, with *watts = 1500 volts × 2 amps*, indicated that there must have been something terrible going on for a few microseconds.

All of these signs were commonly reported by others who had had a "tube short out." Surely an ohmmeter would verify this — but the question was whether the tube shorted out before or during the fireworks.

It did not seem to me that this much fireworks could be the result of contact between the grid and fila-

ment of a zero-bias triode. The fact of the matter is that if you connect a jumper between the grid and filament very little can happen because the two tube elements are practically at zero volts to start with. One thing that does happen is that the exciter will be looking into a short circuit which causes the output of the amplifier to decrease.

There had to be a better explanation for this problem.

The possibility of a parasitic oscillation seemed like a good place to start. Before tubes can oscillate, they need some kind of resonant circuit in the grid path.

Investigation of the remaining 1-mH choke revealed that it had a dc resistance of about 20 ohms and that it had many series resonances when checked with a dip-meter. Since grid-circuit resonances are what we would like to avoid, I substituted a 2-watt, 20 ohm carbon resistor for the choke. The resistor had none of the resonances I found with the choke. I installed one resistor in place of each choke on both tube sockets. As a further precaution against encouraging the grid resonance to reappear, I changed the three 200-pF capacitors on each tube socket to 100-pF, 1000-volt disc-ceramic capacitors.

The amplifier was tried again and it performed nicely — and the gremlins had vanished.

I would not recommend using much less, or much more, than 20 ohms resistance at 2 watts. Another amplifier was tried with 10 ohms and that amplifier had instability problems. Splitting the resistance into three parallel 62-ohm, 1-watt carbon resistors, one from each grid pin to ground, would be a better way to do it.

The tragic thing about all this is *that a really hot tube, that is, one* with lots of gain, is also the one that is most likely to self-destruct by oscillating in an amplifier with a marginal parasitic problem. Fortunately my tube survived, but many tubes do not.

Richard Measures, AG6K

continued from page 8

panied the appearance of the appliance operator who, judging by his language and QSO content, hasn't a clue as to what is going on behind the panel of his transceiver. Perhaps the growing interest in QRP DX, and in weak signal work in general, marks a return to the principles upon which our hobby was born and out of which have emerged most of the significant advances in communications technology.

Thomas W. Sanders, W6QJI
Port Orchard, Washington

short circuits

K2RIW Yagi

"Requirements and Recommendations for 70-cm EME," June, 1982, mistakenly notes that "the K2RIW (432 Yagi) has gone out of production."

The K2RIW Yagi, the original RIW 432-19, is still in production by RIW Products, Box 191, Babylon, New York 11702.

inductance meter

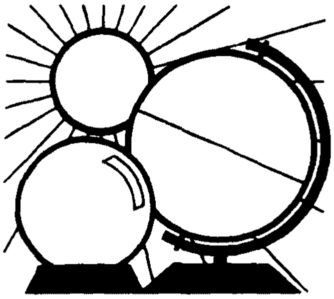
Those readers who would like additional information concerning the parts placement for the inductance meter described in the April, 1982, issue ("Easy To Build Inductance Meter"), should send an SASE to Ed Marriner, W6XM, 528 Colima Street, LaJolla, California 92037.

low-frequency crystal oscillator

The footnote on page 67 of the March, 1982, issue should be disregarded. Crystals are no longer available *from that* source.

half-square antenna

In the article "Half-Square Antenna," page 48 of the December, 1981, issue, note that in **eq. 1** the value for L should be in μH. Also, the design constant should be 25330.



DX FORECASTER

Garth Stonehocker, KØRYW

last minute forecast

The higher frequency bands (10, 15, and 20 meters) are expected to have excellent openings the first and last weeks of the month. Openings will not be as plentiful mid-month, so you should shift DX bands as conditions may be better on the night bands (40, 80, and 160 meters). These bands should steadily improve as winter approaches. Thunderstorm noise quiets down in the northern hemisphere this time of year letting you hear the weaker DX in those night-time openings. Geomagnetic field disturbances, which give so much fading (QSB) and some VHF *auroral* scatter openings, could be evident around the 8th, 16th, and 25th of October.

Since October is still an equinoctial month, these periods of disturbance can be *longer and more intense than* at other times of the year. Don't despair; these disturbed periods can bring special openings to rare DX locations. QSB is evidence of ionospheric movement on a variable time scale. Thus, the angles of reflection are variable, too. These variable angles of reflection are the reason for the unusual azimuths (bearings) from your station to and from the DX station. Just a little more fun, especially if you're patient enough to listen intently for weak signals.

During October the Orionid meteor showers will be visible from the 15th through the 25th. The maximum rate will be 10 to 20 per hour on the 20th and 21st of the month. The moon will be full on the 3rd and will perigee on the 9th, which may interest moonbounce DXers.

Now that the sunspot number (SSN) and solar flux are showing a decided decrease, our DX operating habits need to be reviewed. By 1986, SSN minimum, our use of the 6-, 10-, *and 15-meter bands will be limited, as* each band slowly loses propagation. This change is caused by the ionosphere's height and ion density, varying diurnally, seasonally, and with sunspot cycles (27-day and 10.7-year periods produce the largest effects). A slight increase in height and a 50-percent decrease in ion density usually occurs at middle latitudes by the time of SSN minimum. The maximum usable frequency (MUF) and signal absorption, which sets the lowest usable frequency (LUF) limit, will both decrease. The middle latitude's MUF decreases about 20 percent in the summer, and 40 percent during other seasons. The noise, QRN, will stay constant with SSN, except for subtle changes from climatic weather. The big QRN variations are local, caused by passing weather fronts and thunderstorms.

The 27-day ionospheric variation which you may be following through the solar flux value (from WWV at 18 minutes after the hour) will still be evident. The amplitude of the solar oscillations will gradually diminish. However, the ionosphere, being a balanced energy system, will retain much of its sensitivity to the effects of solar flares or regions.

With all these variations in mind, what DX operating changes can be expected? The highest band for consistent DX will be 20 meters, with occasional openings on 15 meters on high 27-day solar flux peaks. Most 10- and 15-meter openings will be a thing of the past, except for sporadic E short skip in June, July, and August. Sporadic E is not really affected by SSN except for auroral zone effects. The 160-, 80- and 40-meter bands will have some very good openings during night-time hours throughout this minimum SSN period.

band-by-band summary

Ten and fifteen meters will be open for worldwide DX from after sunrise until after sunset during the 27-day solar flux maximum periods. Short skip of 1200 miles (maximum distance) is possible, and will follow the sun across the earth.

Twenty meters will be open to some area of the world for the entire twenty-four hour period on most days of the month. The band should peak in all directions just after local sunrise, and again toward the east and south during late evening hours. During darkness, the band will peak toward the west, in an arc from southwest through northwest, that will encompass Pacific areas.

Forty and eighty meters will be the most usable night-time DX bands. Most areas of the world will be workable from dusk until sunrise. Hops shorten on these bands to about 2000 miles for 40 and 1500 miles for 80 meters, but the number of hops can increase since signal absorption in the ionosphere's D region is low during the night. The path follows the direc*tion of darkness across the earth*, similar to the way the higher bands follow the sun. Short skip can be used during the day and even at night if low-height horizontal antennas (high take-off angle) are used. Vertical antennas over good ground systems give the lowest take-off angles for long skip on bands during darkness.

One-sixty meters will be similar to 80 *meters*, providing good working conditions for enthusiastic DXers who like to work into the wee hours of the night and early morning hours, especially at local dawn.

ham radio

OCTOBER

WESTERN USA

GMT	PDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	5:00	10	20	15	10	15	10	10	10
0100	6:00	10	20	15	10	15	10	10	15
0200	7:00	10	20	15	15	15	10	10	15
0300	8:00	—	—	20	15	15	10	10	15
0400	9:00	—	—	20	15	15	10	10	15
0500	10:00	—	—	20	20	15	10	15	20
0600	11:00	—	—	20	20	20	15	15	20
0700	12:00	—	—	20	20	20	15	20	40
0800	1:00	—	—	—	40	20	15	20	40
0900	2:00	20	—	—	40	20	20	20	40
1000	3:00	40	—	—	40	20	20	20	40
1100	4:00	40	—	—	40	20	40	20	40
1200	5:00	40	—	—	40	40	40	20	40
1300	6:00	20	—	—	20	40	40	—	40
1400	7:00	20	20	20	20	—	40	—	—
1500	8:00	20	20	20	15	—	—	—	—
1600	9:00	15	20	15	15	—	—	—	—
1700	10:00	15	15	15	10	—	15	—	—
1800	11:00	15	15	15	10	—	15	15	—
1900	12:00	15	15	10	10	15	15	15	20
2000	1:00	15	15	10	10	15	15	10	15
2100	2:00	15	20	10	10	15	10	10	10
2200	3:00	15	20	10	15	15	10	10	10
2300	4:00	10	20	15	15	15	10	10	10

MID USA

GMT	MDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)	CDT
0000	6:00	—	20	15	15	15	15	15	15	7:00
0100	7:00	—	20	15	15	15	10	10	15	8:00
0200	8:00	—	20	15	15	15	10	10	15	9:00
0300	9:00	—	40	20	10	15	10	10	15	10:00
0400	10:00	20	40	20	10	15	15	15	20	11:00
0500	11:00	20	40	20	15	20	15	15	20	12:00
0600	12:00	—	40	20	20	20	15	20	20	1:00
0700	1:00	—	—	20	20	20	20	20	20	2:00
0800	2:00	—	—	20	20	20	20	20	20	3:00
0900	3:00	—	—	40	20	20	20	20	20	4:00
1000	4:00	—	—	40	40	20	20	20	—	5:00
1100	5:00	—	—	—	40	20	20	20	—	6:00
1200	6:00	—	—	—	20	20	20	20	—	7:00
1300	7:00	20	20	—	20	—	20	—	—	8:00
1400	8:00	20	20	15	15	—	—	—	—	9:00
1500	9:00	20	15	15	15	—	—	—	—	10:00
1600	10:00	20	15	15	15	—	—	15	—	11:00
1700	11:00	15	15	15	15	—	15	20	—	12:00
1800	12:00	15	15	15	15	—	15	15	—	1:00
1900	1:00	20	15	15	15	15	15*	10	—	2:00
2000	2:00	20	15	15	15	15	15	10	—	3:00
2100	3:00	—	20	15	15	15	10	10	15	4:00
2200	4:00	—	20	15	15	15	10	15	10	5:00
2300	5:00	—	20	15	15	15	15	15	10	6:00

EASTERN USA

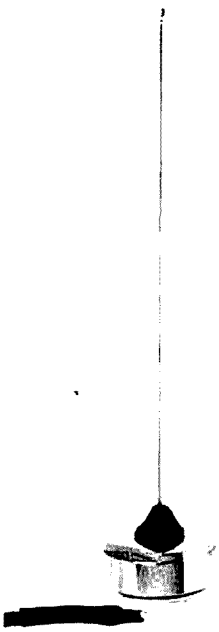
GMT	EDT	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (Caribbean S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	8:00	15	20	10	15*	15	10	10	15
0100	9:00	15	20	10	15	15	10	10	15
0200	10:00	15	20	15	15	15	10	15*	20
0300	11:00	20	20	20	10	15	15	15	20
0400	12:00	20	20	20	10	20	15	20	20
0500	1:00	—	40	20	15	20	20	20	20
0600	2:00	—	40	20	20	20	20	20	20
0700	3:00	—	40	40	20	20	20	20	20
0800	4:00	—	—	40	40	20	20	20	—
0900	5:00	—	—	40	40	—	20	20	—
1000	6:00	—	—	20	40	—	20	—	—
1100	7:00	—	—	20	40	—	20	—	—
1200	8:00	—	15	20	20	—	—	—	—
1300	9:00	—	15	15	15	—	—	—	—
1400	10:00	20	15	15	15*	—	—	—	20
1500	11:00	15	15	15	15*	—	—	—	20
1600	12:00	15	15	15	15*	—	—	—	—
1700	1:00	20	15	15	15	—	—	—	—
1800	2:00	20	15	15	15	—	15	—	—
1900	3:00	20	15	15	15	15	15	—	—
2000	4:00	—	15	15	15	15	15*	15	—
2100	5:00	—	15	15	15	15	15	15	15
2200	6:00	—	20	10	15	15	15	15	15
2300	7:00	—	20	10	15	15	10	10	15

*Look at next higher band for possible openings.

NEW products

low-cost quarterwave antennas

With the addition of two new quarterwave antenna series, the Antenna Specialists Co. now provides the mobile radio industry with a variety of quick install economy antennas, offering excellent performance in both VHF and UHF. The new quarterwave antennas require no field tuning and can be mounted in several configurations, especially important for today's smaller cars.



The ASP-1610 unity gain series covers UHF from 406-512 MHz. It will accept 150 watts of power and exhibits VSWR of 1.5 to 1 or better. The stainless-steel radiator, approximately six inches long, ensures long life and service-free operation.

The ASP-1410 series covers the 136-174 MHz VHF band. They are factory tuned to eliminate field adjustment. Power rating is 150 watts maximum, with VSWR of 1.5:1 or better.

Both series are available in low-profile rooftop, magnetic, or trunk lip mounting configurations. A low-profile conversion model, less cable, also is available in each series. For more information, contact Marketing Department, The Antenna Specialists Co., 12435 Euclid Avenue, Cleveland, Ohio 44106.

rf intermodulation evaluation

AST's program for evaluating intermodulation between several transmitters, written in BASIC, will run on many popular personal computers (TRS-80, APPLE II, etc.). Up to 100 frequencies may be processed at one time, and products up to the 99th order may be generated under operator control. Even and odd orders, as well as in-band and out-of-band products, are supported. The width of the comparison window can be adjusted by the user, and image frequency checking is performed automatically.

A version of the program is available for the HP-41C programmable calculator.

Documentation and source listings are $59.95, source with diskette or mag cards is $79.95. For more information, contact Advanced Signaling Technologies, Inc., 5909 E. Pima Street, Tucson, Arizona 85712; telephone 602-296-8603.

pulse/peak/CW rf wattmeter

The model 4391 RF Power Analyst digital directional wattmeters measure peak pulse power and peak envelope power in addition to CW power during normal equipment operations. Ruggedly designed for pulsed rf systems such as avionics surveillance, collision avoidance, navigation, radar, command control communications, and telemetry, they need no attenuators, directional couplers or charts.

Based on the Thruline principle and using the same plug-in elements for frequency and power level selection, the model 4391 reads incident and reflected CW power in watts or in dBm, incident and reflected pulse power in watts, calculates VSWR, dB return loss and percentage modulation, remembers maximum and minimum parameter levels during equipment adjustment and overranges at least 20 percent beyond nominal full scale.

Frequency and power ranges in either peak or CW modes are 0.45-2300 MHz from 0.1 to 10,000 watts. Pulse parameters range from a duty factor of 1×10^{-4}, a repetition rate of 25 PPS, and a pulse width of 0.8 microseconds, all the way to square wave or CW.

The price of model 4391 RF Power Analyst is $775. Plug-in elements from $45 to $100. For more information contact Bird Electronic Corporation, 30303 Aurora Road, Cleveland (Solon), Ohio 44139.

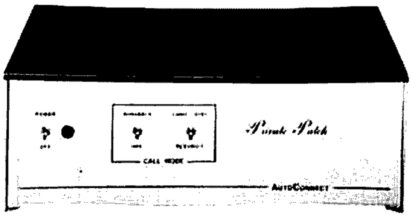
squelchless autopatch

Private Patch is a full-featured autopatch product requiring no options. It does not employ the sampling technique, so there are no annoying, repetitious squelch tails.

In addition to excellent simplex capability, our audio and digital signal processing technique also permits operation through range-extending repeaters. Any repeater which will carry voice will work. A five-digit user-programmable access code and long-distance operator-restrict switch protect your phone bill. The front panel ringback switch permits incoming calls when desired.

Private Patch requires no modifications to your fm base transceiver. It connects to microphone and speaker jacks. No timing adjustments are needed due to a fully digital design approach.

Additional features: 115 Vac supply; CW identification; six minute shutdown timer in case you drive out of range — resettable with reset code



for additional talk time; CMOS digital circuits, forty integrated circuits, sixteen transistors, etc., on one high quality glass circuit card; positive control logic; modular phone jack; modular phone cord; Touchtone® decoder tolerates wide range of level and twist — decodes up to ten digits per second — will not false.

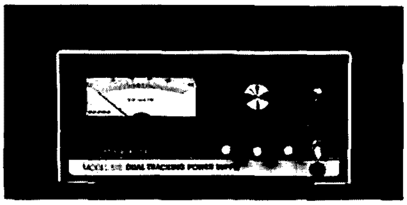
Private Patch is sold at an introductory price of $489. For more information, contact AutoConnect, P.O. Box 4155, Torrance, California 90510; telephone 213-540-1053.

dual tracking power supply

HF Signalling, Inc., is proud to announce the new Model 515 dual tracking power supply. Designed for modern solid-state applications where both linear op-amp and digital IC circuits are encountered, output voltage is variable from ± 5V to ± 15Vdc and each output is rated at 1 amp continuous to comply with power requirements of complex digital and analog devices. All outputs feature automatic current limiting and short-circuit protection as well as reverse voltage protection.

The Model 515 is manufactured with controlled tracking to within 20 mV and has a load regulation better than 0.3 percent from no-load to full-load on all outputs. Engineering labs, student labs, experimenters, and hobbyists also appreciate the large meter for easy voltage calibrations. In addition, HF Signalling, Inc., warrants each instrument that it manufactures to be free from defects in material and workmanship under nor-

NEW products



mal use and service for a period of 120 days from the date of purchase.

For more information, contact HF Signalling, Inc., P.O. Box 17510, Kansas City, Missouri 64130; telephone 816-931-4448.

monitoring accessory catalogue

An all-new twenty-page catalogue of communications monitoring accessories and publications is now available from Grove Enterprises. Featured are several innovative receiver add-ons designed to enhance the listening quality of both professional and non-professional monitors.

New products include a frequency-selective antenna tuner for the 10 kHz through 30 MHz spectrum, a scrambled speech decoder with an adjustable deep notch tone interference filter, a dual scanner antenna coupler, and a unique 30-960 MHz tabletop active antenna/preamplifier designed especially for apartment or other hidden-antenna users.

More than twenty products including antennas, filters, couplers, converters, preamplifiers and hard-to-find books and frequency lists make this catalogue "must" reading for the serious communications monitor.

For your free copy write Grove Enterprises, Inc., Dept. D, Brasstown, North Carolina 28902; telephone 800-438-8155.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contents

Observation & Opinion

Meet *ham radio*'s technical editor and the latest addition to the *ham radio* staff: Rich Rosen, an active ham for a quarter century as K2TXC and K2RR. He's lived in, visited, or operated from most of the States as well as thirty foreign countries. Rich was part of the K2GL contest team in the late 50s/early 60s, and was a commercial CW op in the U.S. merchant marine and at RCA coastal station WNY. Professionally a double-E for sixteen years (MSEE) and a registered engineer (P.E.) in New York and Colorado, he has worked for the aerospace firms of AIL and Hughes Aircraft and for a Naval architecture company designing power, lighting, and communication circuits for auxiliary vessels and submarines.

Rich worked as a video/audio development engineer at CBS Television Network, and was responsible for over two hundred installations of 3.7-4.2 GHz TVRO and terrestrial point-to-point microwave circuits at Hughes. In the publishing industry, he has served as editor and associate publisher of *rf design* magazine, consulting editor for CM, Global Communications, Satcom, and TVC, and as Western editor of *MicroWaves* magazine. He recently published the book *From Beverages Thru OSCAR — A Bibliography*.

When it comes to propagation phenomena, most Radio Amateurs have heard of D, E, and F layers. But what about the lesser known C and G layers, or the E_1, E_2, and $F_{1\frac{1}{2}}$ regions of the ionosphere? Why, when 10 meters first opens to "Europe," do we sometimes have to point our beams toward North Africa to work England? It's common knowledge that solar flares inhibit hf communications and can even cause a radio blackout, but what accounts for the sudden *enhancement* of hf propagation at the beginning of the flare? These and other such questions will be answered by an authority on magneto-ionospheric effects. *Ham radio* magazine, introducing a new feature, is pleased to present in-depth interviews with experts in fields of direct and applicable interest to hams. Look for them soon.

Ham radio magazine is also making ready to provide you, the reader, with a forum — a place to direct your technical questions. Starting this January and called the Technical Forum, this new feature will consider questions on subjects ranging from Beverage antennas through PFM laser communications systems and beyond. Because space is limited, the majority of questions researched will be chosen on the basis of widest interest and need.

If, for example, you've always wanted to know where to find a TVI suppression circuit for the "signal shifter," we'd be glad to tell you to look in the March, 1955, issue of *QST* on page 32. In the unlikely event that your question stumps us, we will print the question in the next available issue and throw it open to our readership to answer. The first reader to respond — correctly — will receive our thanks and a gift. Start sending in your questions now.

Here's a preview of a few of the subjects you'll be seeing in the upcoming issues of *ham radio*: a detailed report on new-band 10 MHz propagation by one of the few U.S. Amateurs permitted to operate there; low-noise preamplifiers for 2304 MHz; Bragg-cell receivers; a 15-meter transceiver for $100; a simple, simplex autopatch; repeater antenna beam tilting; a remote receiver-site voting system; and a simple way of locating geostationary satellites.

Some of our older readers may recall the editor of *R9* and *Radio* magazines (pre-W.W.II), the author of the 1948 *Antenna Manual* and originator of several popular wire hf antennas: Woodrow W. "Woody" Smith, W6BCX. Woody will tell us about the history and development of the popular bobtail curtain antenna in an upcoming issue — and about the antenna's most recent adaptations, too.

We encourage, from among the international community of hams, the authors of articles that have appeared in foreign magazines and journals to share with us their technical achievements and views. We are eager to hear from Amateurs who have written for such publications as *Radio Communications* (England), *Break-In* (New Zealand), *Ondes Courtes Informations* and *Radio* (France), *Radio Rivista* (Italy), *Revista Telegrafica Electronica* (Argentina), *CQ DL* (Germany), and *CQ Ham Radio* (Japan). Our multilingual staff will work with you.

It was a pleasure meeting some of you at the recent Boxboro, Massachusetts, ARRL show, and I look forward to discussing any technical subject with our readers — by phone, letter, or face to face.

Rich Rosen, K2RR
technical editor

by Skip Tenney

If you've been looking at our masthead during the past month or so you've probably noticed a number of changes. Much of this was the result of a decision earlier this year by Alf Wilson, W6NIF, that it was time to head back to California and enjoy some of that well-earned retirement that we had so rudely interrupted a couple of years ago. Thanks, Alf, for a lot of help and for a chance for all of us to work with one of the real pros in our industry.

First is the appointment of Marty Hanft, KA1ZM, as the editor of *ham radio* magazine. Marty has served us in several important editorial positions starting as our administrative editor some years ago. Most recently he has been our managing editor. He is our resident expert in seeing that we have the best reading and best looking publication in the field and one that is properly completed on time month after month. Congratulations, Marty! You've earned your new responsibilities and earned them well.

Another important change is the addition of Deb Marshall to our staff as managing editor. She comes to us with an excellent background in technical publishing. Her experience includes having been the managing editor of *80 Microcomputing*, and she continues to find time in her busy schedule to be editor of *Bar Code News*, an interesting publication in the small computer field. Deb gave us a good hand over this past summer and we have come to depend on her as a real professional and a very important part of the *ham radio* operation.

Certainly one of the most critical positions with any publication such as *ham radio* is that of technical editor. That is the person who has the greatest control over the actual content of the magazine and the one who has a very great say as to the direction it takes. We have been extremely lucky to have acquired the very enthusiastic services of Rich Rosen, K2RR, as our new technical editor and associate publisher.

Rich brings to us a superb background including having been the editor and associate publisher of *rf Design*, a highly regarded industry magazine. He has also put in many very successful years as an engineer working in a variety of projects from VLF to microwaves. His Amateur background is also extensive. It includes every type of activity from very successful 75-meter DXing to his being both an operator and designer of one of the East's most successful major contest stations a few years back. Rich has so many exciting new ideas that all of us, both reader and *ham radio* staff alike, are really going to have to go some to keep up with the pace he will be setting for all of us.

As you can see we've been doing some real planning, and, over the next few months, I think you'll agree that more than ever before *ham radio* will be the one magazine setting the standard for everyone else to follow.

Skip Tenney, W1NLB

comments

training deaf hams

Dear HR:

I am looking for information on very simple transmitters and receivers in the 160-190 kHz band. I want to establish a training network for deaf persons so they might eventually obtain ham licenses. The equipment must be simple, easy to build, and inexpensive.

I have some military surplus BC-1208-CM receivers which need 28 volt power supplies and frequency converters from 200-400 kHz to 160-190 kHz, or plans for padding the variable capacitors down. I would like to obtain some military surplus BC-453's to try out. Do you know where I might find the latter?

Most people suggest very expensive modern equipment, which would be a severe deterrent to the success of my program.

Any help you or your readers can give will be appreciated.

Bob Real, KA6LBG
1781 North Grand Avenue
Porterville, California 93257

credit Pythagoras

Dear HR:

As both an avid reader of *ham radio* and also a college physics teacher for eighteen years, I wish to applaud the imaginative use of Fresnel diffraction, as suggested by William Brooks, WB6YVK, in the May, 1982, issue.

ter's error which misrepresented the line segments in **eq. 1** which should be rewritten to read, I believe:

$$(S_n + d_n) - (S_o + D_o) = n\lambda/2 \quad (1)$$

Brooks states that "trigonometry" leads us to **eq. 2**. However, while trigonometry surely relates to right triangles, I believe it is better to give Pythagoras the credit for **eq. 2**, since he proved the relation among legs and hypotenuse of a right triangle before trigonometry became tabulated in tables of sines and cosines. We might save a few readers who feel geometry is within their scope but not trigonometry by making the more modest claim.

Of course, the binomial expansion, from which derive **eqs. 4** and **5**, applies only in the approximation that R_n is much smaller than the values of S or D.

It should be possible to obtain some lightweight insulation material which includes radiation-reflective coating — such as is used in housing construction. Such would be convenient as a material for building the proposed zone plate.

David A. Cornell, K9BO
Elsah, Illinois

*K9BO is indeed correct, there is an error in **eq. 1** which should read:*

$$(S_n + d_n) - (S_o + D_o) = n\lambda/2 \quad (1)$$

The remaining equations are correct as printed.

As for geometry versus trigonometry, my McGraw-Hill Dictionary of Physics and Mathematics (1978) *defines geometry as "the qualitative study of shape and size." I would direct K9BO's attention to the bold type geometry above the paragraph containing **eqs. 2** and **3**. Further, my dictionary defines trigonometry as "the study of triangles and the trigonometric functions." **Fig. 2** and the supporting text are discussed in terms of triangles. I disagree with K9BO's contention that trigonometry is beyond some readers. I suspect that a large majority of* ham radio's *readers are licensed hams, and as such must have become somewhat familiar with trigonometry to have successfully confronted questions concerning phase angle, power factor, antenna dimensions, etc. in the license examination.*

William M. Brooks, WB6YVK
San Jose, California

QRP

Dear HR:

Thank you for your fine editorial on QRP in the April issue. You have thrown down a challenge — who will be the first U.S. ham to earn a WAC with 500 mW on the new WARC bands? Several active QRPers are gearing up to do so.

The points raised in your editorial are all well taken and right on target. You might get some argument, however, when you say that anything below 1 watt is QRP_p. Generally, anything less than a watt output is in the milliwatt category, while QRP_p is looked on by many low-power enthusiasts as being between mW and five watts input.

For those of your readers who would like additional information on low-power operations, QRP Amateur Radio Club International offers a free brochure. A large SASE sent to the club at Box 12072, Capitol Station, Austin, Texas 78711, will bring a copy by return mail.

Fred Bonavita, W5QJM
Austin, Texas 78711

Orlando Hamcation '83

Dear HR:

The readers of *ham radio* may be interested to learn that the 1983 Orlando Hamcation will be held on March 18, 19, and 20, 1983, at the Orlando Centroplex-Expo Centre.

Expo Centre is a large and modern exhibition hall, with roughly 100,000 square feet of available space; it's air conditioned, has a top-notch PA system, room for 400 to 500 indoor flea market spaces, and lots more.

We expect the 1983 Orlando Hamcation to be the best ever, and we thought you'd like to pass the word along to your readers.

Al Canning, Chairman
Orlando Hamcation

presstop de W9JUV

UOSAT IS BACK IN OPERATION, following a successful command operation using Stanford Research Institute's 150-foot dish on September 20. The experiment-laden British Amateur satellite had been locked up since April, when both its 70-cm and 2-meter beacons were accidentally activated simulaneously during a checkout. The resultant desensing of both command receivers prevented control stations from re-establishing control of the bird—until SRI's giant dish, with its 42-dBd gain at 70 cm, enabled a California team to hit UOSAT with at least 12 megawatts ERP. A midnight call to G3YJO brought the good news to England, and subsequent checkouts by UOSAT's University of Surrey Command Station have determined that it's little worse for its five-month "hibernation." With an estimated half to two-thirds of the satellite's useful life still remaining, expectations are now that most of the original mission of the sophisticated satellite will be accomplished.

The Failure Of The L5 Ariane Satellite to achieve orbit on September 10 provided a contrastingly negative note to the Amateur Radio space program, however. A faulty hydrogen pump in the Ariane's third stage is believed to have been the cause of the failure, which brought the space vehicle down into the Atlantic. Though some users had expressed concern over Ariane's future as a result of this latest loss, it now appears that the failure may actually advance the launch of the Phase 3 Amateur satellite because L7, the vehicle Phase 3 is scheduled to ride, may be moved up to early next year. For various technical reasons L6, the next Ariane in line, can't be launched that soon.

An Amateur Satellite Technical Meeting, the first of its type ever held, is set for October 2 in Paris. The three-day meeting will permit Amateur satellite builders from the U.S., France, Germany, the U.K., South Africa, Japan, Hungary, and possibly elsewhere to discuss on a purely technical basis future cooperative efforts and launch opportunities.

AMATEUR EXAM ADMINISTRATION WON'T BE CHANGING very soon, despite the President's having signed the Omnibus Communications Bill into law September 13. The ARRL is studying procedures and costs for preparing and administering exams, and it should be submitting a Petition for Rule Making on the subject in October. This should result in a Notice of Proposed Rule Making from the FCC, with appropriate Comment and Reply Comment periods eventually leading to a Report and Order, spelling out procedures. The time required by the steps in this process will push the resolution into next spring at the earliest, and more likely later in the year. With current FCC staff and money reductions, however, it's possible that some FCC Field Offices could be closed before Amateurs are ready to step in.

Novice Exams May Be Changed Soon. A new procedure in which the volunteer examiner simply certifies the would-be Novice has passed both theory and CW tests would be sufficient to qualify him for a license, eliminating much FCC paperwork. This change will probably surface before the end of the year, most likely as an NPRM.

Directions For A No-Code Amateur License seem to be shifting within the Commission, with a Canadian-type "Digital" UHF license now favored over a "No-Code Technician."

PEP RF POWER MEASUREMENT has been proposed for the Amateur service in an NPRM just released by the FCC. PR Docket 82-624 proposed deleting present requirements that an Amateur have power-measuring equipment, and will specify how FCC engineers would measure it during a station inspection. Due date for Comments had not been released at press time.

Various New And Experimental Digital Codes have been authorized above 50 MHz by the FCC in a Report and Order on PR Docket 81-699. In addition to opening up a variety of new techniques, this action also marks the first time the Commission has permitted the general use of modes that its Monitoring Stations were not equipped to copy.

10-MHZ AUTHORIZATION FOR U.S. AMATEURS has still not cleared the FCC Commissioners as this goes to press, but the necessary paperwork is believed well on its way through the FCC and could be approved as soon as mid-October. Though Amateur access to the new band could then be granted immediately, it's most likely it won't come until thirty days after Commission approval. Barring unexpected developments, U.S. users of the new WARC band will be limited to CW and RTTY at a maximum input of 250 watts.

Access To The New 18 And 24 MHz Bands won't be coming along for some time, however. Unlike 10 MHz, which the WARC made available last January 1st, the other two new HF bands are to be released to the Amateur service in a much more gradual fashion, giving their present users years, if necessary, to move to other frequencies.

A SUIT AGAINST BURBANK, ILLINOIS, WAS FILED on September 10 in U.S. District Court for the Northern District of Illinois on behalf of ten Burbank Amateurs and CB operators by attorney W9WU. The suit against village officials and their recently enacted ordinance restricting antennas and interference included as a late addition N8DRN, who recently moved to Burbank to become pastor of a church there. He'd been refused an antenna permit that he'd wanted so as to continue communications with his colleagues in Nigeria, where he served his church for twenty years and had been very active as 5N6ENV.

Burbank Officials Have Until October 20 to respond to the suit.

the SS-9000 — Heath's new all-band transceiver

ham radio looks at Heath's newest and finest offering

When a top-ranking Amateur radio equipment manufacturer announces its first new all-band transceiver to be put on the market in eight years, that's news. When that new rig is completely solid-state and includes virtually every feature anyone ever dreamed of for such a radio, that's important news. When that new radio is the first Amateur transceiver specifically designed to be just as much at home interfaced to a computer as with a human operator at the front panel controls, that's more than just news — it's a major story!

Word that this important new radio was finally complete reached *ham radio* this spring, when several top Heath officials visited Greenville and discussed it on a confidential basis with members of the *ham radio* staff. Our enthusiastic reaction to their description of the new (completely manufactured — not a kit!) SS-9000 transceiver was duly noted, as was the subsequent suggestion that the SS-9000 constituted such a significant advance in Amateur equipment it could be considered for major editorial coverage. Several months and many long-distance phone conversations later, the arrangements were complete. *ham radio* was to get the first outsider's look at the SS-9000, in a no-holds-barred session from which we could write a frank appraisal of what Heath has done.

Thus it was that a hot August day found me in Benton Harbor, admiring the forest of towers and beams perched on one corner of Heath's sprawling plant just a stone's throw from the shore of Lake Michigan. Inside the plant, PR Coordinator Myron Kukla took me to the engineering department and introduced me to Dave Poplewski, KC8IV, and Jerry Tolsma, W8GPB. Dave and Jerry are the two Heath people who have been most directly responsible for the development of the SS-9000, and Dave is Heath's Product Line Manager of Communications.

Dave filled me in on the history of the SS-9000 in a very frank, candid discussion, and a very interesting story (which we'll touch on a bit later) it was. Heath had thoughtfully provided me, before my visit, with a draft copy of the preliminary operator's manual as well as a complete set of schematics for the SS-9000. I'd spent an evening studying them, so I thought I was pretty well prepared for my introduction to the real radio. I was wrong. You just can't fully appreciate an Amateur transceiver being operated by a computer until you see it happen! But before getting to that, let's talk about the SS-9000 as a radio.

By Joe Schroeder, W9JUV, associate editor, *ham radio*

band	tuning range
160 meters	1745-2055 kHz
80 meters	3425-4075 kHz
40 meters	6925-7375 kHz
30 meters	10100-10150 kHz
20 meters	*13925-15008 kHz
17 meters	17699-18200 kHz
15 meters	20925-21760 kHz
12 meters	24890-24990 kHz
10 meters	28000-29700 kHz

*transmit inhibited on high end

table 1. SS-9000 frequency coverage.

The SS-9000 is a microprocessor-controlled, all solid-state 100-watt output SSB, CW and RTTY transceiver that covers all nine Amateur bands from 160 through 10 meters. The specs are good (see **table 1**), and though an afternoon playing with a radio is no substitute for a laboratory evaluation, my gut feeling (reinforced by Heath's reputation) is that they're probably conservative. The SS-9000's styling is very attractive, with the control layout logical and easy to get used to and use.

Tuning is digital, in 100 Hz steps, using a smoothly operating knob-driven optical encoder that can be adjusted for drag to suit an individual operator's taste. One unique feature that's immediately obvious is the dual-frequency display, with pushbutton selection of either of the two displayed frequencies for transmit, receive, or both (transceive). A pair of push buttons below the tuning knob scan up or down whichever display is in the receive mode, at a rate determined by a DIP switch programmer located inside the top cover of the radio. In addition to the two displayed frequencies, there is a memory in which one additional frequency for each band may be stored.

The memories in the SS-9000, including the two frequencies in the display, are non-volatile, so even when the radio is turned off and then turned on again all the frequencies to which it was last tuned are there. Each band has its own memories, so not only the last used (and last stored) frequencies on the last band to be operated, but also those frequencies on all *nine bands* (twenty-seven *frequencies* total) are preserved. This would be a tremendous convenience for anyone who keeps regular schedules with friends or participates in nets. It would also give a DXer looking for a DXpedition that's been active on a variety of known frequencies on a number of different bands a real advantage over his less well-equipped competition.

transmitter

Dave calls the final "the world's most protected PA," and it's easy to see why after you read the specs and watch it demonstrated. Unlike so many solid-state PAs, the one in this rig will deliver power into any load it sees. It's guaranteed to deliver eighty percent of rated power into a 2:1 mismatch, and at least 15 watts into any load. I saw it delivering 25 watts into a 5:1 mismatch. It's also protected against excessive temperature and current.

There is a front panel power output control, for adjusting the output on any mode from about 1 watt to full (100 watts) power. For use with a transverter, there's a rear panel jumper to disable the final, resulting in a maximum output at the antenna terminal of about 50 mW from the driver stage. There's also front panel adjustment of speech compression, VOX (and CW) delay and mike gain. The front panel meter provides switch-selected monitoring of ALC, power output and compression on transmit as well as signal strength on receive.

receiver

The receiver has RIT (+/−250 Hz) and passband shift. The passband shift can be used only on SSB, and is adjustable in 100 Hz steps from −600 to +400 Hz. For CW, two very effective filters (400 Hz medium and 200 Hz narrow) are provided. In the CW wide mode the 2.1 kHz SSB filter is in the circuit. On RTTY the 400 Hz CW filter is used. There's also a noise blanker switch selection of slow, fast, or no AGC, and AF and rf gain controls.

The receptacle for the external power supply, an SO-239 for the antenna, and a key jack, are located on the back panel. There's also the usual array of jacks for switching external relays, muting and ALC for operating an external amplifier or other accessories. High and low level receive audio and high and low impedance transmit audio jacks are also provided for use with a RTTY terminal or phone patch. A jumpered plug determines full or low (about 50 mW) transmitter power output, providing a means for automatically switching to low power when an accessory transverter is used.

Just above the antenna connector on the rear panel is a square box. This is the motor drive for the band switch (remote band switching!). There's even better news: using Heath's SA-1480 remote coax switch with the SS-9000 provides automatic antenna selection whenever the band switch is turned manually or remotely with the motor drive. Interconnection between the transceiver and antenna switch is by means of a ten-conductor ribbon cable that plugs

into the top of the motor drive box; when desired, automatic antenna switching can also be disabled from the SA-1480's front panel.

computer interface

What sets the SS-9000 apart from every other Amateur rig on the market is the 25-pin connector marked TERMINAL that's located at the top of the back panel next to the key jack. This connector is the type known to computer buffs as the DCE (DB-25S), and provides the SS-9000 with serial RS-232C interface for use with a computer, RTTY, smart terminal or modem. My introduction to the added capabilities of computer control was with an SS-9000 interfaced with a Heath H/Z-89 computer booted up with a demonstration program. After responding to the computer's request for my call and handle, the computerized SS-9000 got very friendly, alternately directing me to perform various control functions from the computer keyboard and performing others itself. Seeing an all-band rig selecting bands, frequencies and modes, then fine-tuning those selections without the hands-on help of an operator is an impressive, if somewhat disconcerting, sight!

We switched to a Heath H-19A smart terminal for further remote exercises. I first called up a listing of all twenty-seven frequencies in memory (three each on nine bands); these were displayed on the terminal's CRT. With a few more keystrokes I put the SS-9000 on 20-meter USB, listening on 14195 and ready to transmit on 14205 (just in case some DXpeditioner was on the band, handing out a new country). Some off-frequency chatter came through the speaker, but with a few more keystrokes I had a rag-chewing VE tuned in. A few more keystrokes moved the passband tuning a few hundred hertz, neatly eliminating some irritating off-frequency splatter in the background. This was fun!

Heath's versatile SS-9000 covers 160 through 10 meters, and can be operated from a computer or smart terminal keyboard just as easily as from its front panel.

Every control function of the SS-9000, with the exception of turning the rig on, can be called up and its status displayed on the computer or terminal CRT. Every control function can then be reset with a few keystrokes. Included are: band switch; mode switch; receive frequency; transmit frequency; transmit (command); receive (command); receiver passband shift; and baud rate. The terminal can also request and display all frequencies stored in memory, and call up and display all SS-9000 switch settings, whether manually set from the rig's front panel or changed through interface commands.

With this powerful control capability there would seem to be no end to what could be done with an SS-9000 and a computer. Dave suggested (only half in jest) a phone booth ham station. With suitable audio I/O to the rig, you could simply step into a phone booth with a portable terminal and modem, dial up your hamshack phone, and go on the air on whatever band and mode you chose for as many contacts you may wish. A rabid DX-chaser could program the rig to check known frequencies for a rare station or DXpedition (after programming the computer to recognize a given call sign or prefix on CW) and stop searching and give an alarm when it's heard. There seems to be no end to the possibilities!

accessories

Other than a computer or smart terminal and the SA-1480 remote coax switch, the PS-9000 power supply is the only major accessory for the SS-9000. In addition to providing 25 amps (peak) at 13.8 volts in a well regulated, fully protected circuit, the matching style PS-9000 also contains the speaker for receiver audio and CW sidetone plus two digital clocks. Though both clocks can be programmed for either twelve or twenty-four hour format, in most shacks one would be set to GMT with a twenty-four-hour presentation and the other on local time with twelve-hour format. Power on/off is normally accomplished from the SS-9000 front panel with a switch on the af pot, though an off/on switch is also provided on the bottom of the PS-9000.

history

The SS-9000 almost came on the market (less computer compatibility and some other bells and whistles) in 1979 as the SS-8000. The SS-8000, developed as a very sophisticated replacement for the

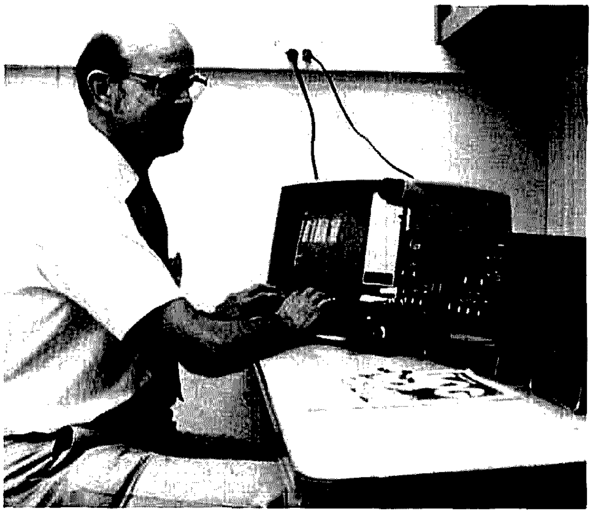
SB-104, was the result of several years of intensive research and development. It was all set to debut; a teaser announcement had appeared in one Heath catalog, the company was making no secret of the fact they were about to spring a super new rig, in fact, they had even discussed the product in detail with *ham radio* editors, when a bombshell struck! Delegates to the 1979 World Administrative Radio Conference agreed there should be three new Amateur HF bands, and these frequencies were in direct conflict with the conversion scheme so carefully worked out for the SS-8000!

Heath went back to the drawing boards, but it soon became painfully clear there was no way the SS-8000 could accommodate the new bands without making performance compromises Heath was unwilling to pass on to its customers. Despite a tremendous investment in development and tooling, the SS-8000 was scrapped.

The many good points of the SS-8000 design had not been forgotten, however. Heath still wanted a new, top-of-the-line, all-band Amateur transceiver, so when it was suggested Heath manufacture a new radio incorporating all the features developed for the SS-8000 but designed to accommodate all the hf Amateur bands, old and new, it received a warm welcome. There was one very significant addition, however: with Heath's very successful entrance into the computer market, this new rig was not only to be microprocessor based but would be fully computer compatible. Work began on the new project almost two years ago, and the SS-9000 is the result. The gang at Heath know they perform, too — SS-9000 prototypes worked both the Sweepstakes and 160-meter contest late last year!

A factory-wired Amateur rig is not a totally new concept at Heath. The SB-101 was offered completely factory built and tested, as well as in kit form, in the 1960s as the SBW-101. (If you still have an SB-101 and it has riveted boards, you've got an SBW-101.) But Heath has always been the great kit house. Why provide the SS-9000 only factory wired? Dave, Jerry and I discussed this at some length. A radio with this degree of sophistication would be a major undertaking for even the most competent home builder. Construction time could run into hundreds of hours, and debugging and checkout requires instruments not available to most Amateurs. Although some Amateurs could indeed assemble an SS-9000 and make it work, the feeling was that all too many could become frustrated in their efforts and cause a tremendous support problem for Heath.

Heath is offering the SS-9000 with a one-year warranty, so they certainly have faith in it as assembled in Benton Harbor!



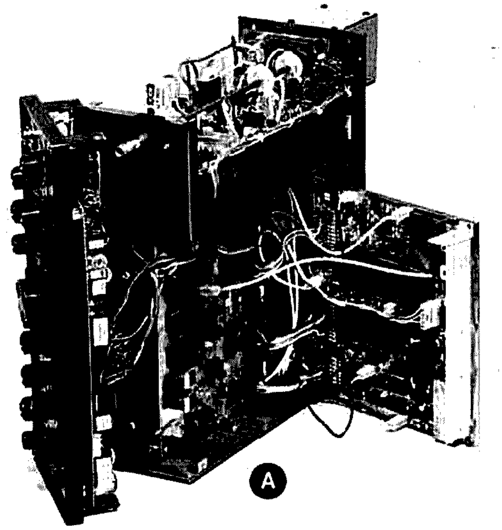
ham radio Associate Editor W9JUV at the controls — that is, keyboard — of the SS-9000. Band (and antenna) selection, tuning and scanning and transmit/receive can all be done from the microcomputer keyboard or from the front panel knobs.

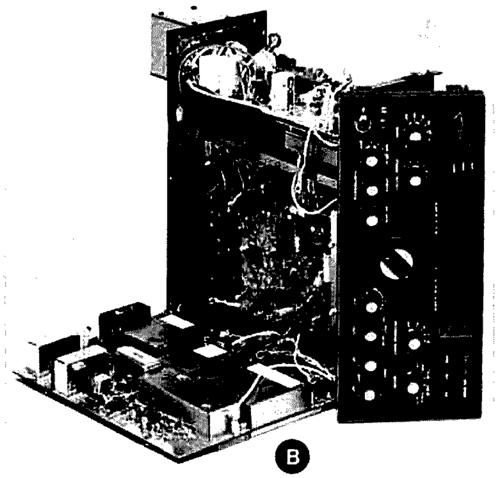
We opened up an SS-9000, and I was immediately impressed by the relative ease of internal access the rig provides. Unlike so many contemporary radios, the SS-9000 is built with hinged boards that swing out of the way, providing access to almost every part of the radio for service or checkout, even with power applied. Not even special adapter boards are required! I commented that such easy access would make it easy for a user who wanted to bring out the 9 MHz first i-f to one of the spare rear panel connectors for a panadapter, for example, to do so.

Dave replied that modifications will not be encouraged, since anything a user does inside the radio will void the warranty. It's entirely the Service Manager's decision as to whether a modification caused the problem that brought the radio back for service. If a user who had made changes in his SS-9000 (or any other Heath gear for that matter) ever does have to return it for service, it's very important that he include a note describing the changes and their purpose and whether he feels they're related to the problem.

summing up

I like the SS-9000. In fact, I like the SS-9000 very much. I like the way it handles and feels on both CW and phone. I liked the way I immediately felt at home with it, despite all its sophistication. It's a radio that I as a CW (and sometimes SSB) DX chaser, OSCAR user, and casual weak-signal VHF buff would like to have on my operating table. Most of all, I'd like to





One of the many nice features of the SS-9000 is its ease of access. The boards fold out without having to be disconnected, so almost every part of the circuitry and all test points and adjustments are available with the radio operating. Shown fully opened up from top (A) and bottom (B).

have it there because it would not only do all those things well, but because of the computer interface.

The possibilities that the SS-9000 opens up seem limitless, and with a new computer in my hamshack/office, I'd dearly love to see how well I could marry the two! Heath thoughtfully provides the necessary information for interfacing the SS-9000 with computers and terminals other than theirs, by the way. Anyone who buys an SS-9000 and doesn't already have some kind of computer with an RS-232C interface has to buy at least a smart terminal as well. The SS-9000 is a fine radio by itself, but it opens up a whole new world with CRT and keyboard attached!

Was there anything I didn't like about the SS-9000? Yes, in fact, there are several things I object to:

1. Frequency coverage: As shown in table 1, the frequency spread on different bands ranges from only 50 kHz on 30 meters to 1700 kHz on 10. By contrast, 20 meters goes from well below the band to 15.008 MHz, to include WWV's 15 MHz signal. These limits are burned into the synthesizer ROM, but why did some have to be so restricted on most bands? Why couldn't they all be as well-designed as 20? Another 100 kHz on 30 meters would have added the ability to receive the 10 MHz WWV signal, a significant addition in a few years when most of the sunspots go away.

2. Frequency display on transmit: The frequency displayed is always the receive frequency, even on CW or RTTY transmit. The CW transmit frequency is actually 750 Hz higher than shown on the display, while on RTTY it's offset by the AFSK frequency. I like to know where I really am, without mental arithmetic.

3. Lack of passband shift on CW: I prefer to use as wide an i-f bandpass as practical on CW, and being able to shift a strong nearby signal out of the passband is a real plus. Unfortunately, the SS-9000's logic doesn't permit this luxury. The good news is that its CW filters are so good I'd probably soon forget I ever wanted passband shift on CW.

4. Scan rate and availability: The slowest scan rate on the SS-9000 is 2.5 kHz per second, and it's internally programmable up to 270 kHz per second! My new 6-meter rig scans at a bit under 1 kHz per second, and that's just about right to stop the scan in time to catch a signal that's popped up on a previously dead band. I think the slow 2.5 kHz per second rate is much too fast, and the fifteen selectable higher rates are essentially useless. I'd also like to see the scan up/down switch contacts brought out to a rear panel connector, so with a two-switch control box I could lean back in my chair and tune the band without having to reach across the table.

None of those are terribly damning complaints, however, and after having spent just one afternoon playing with an SS-9000 at Heath, I realized that

Frequency — Two six-digit electronic displays.
Readout Accuracy — To the nearest 100 Hz.
Frequency Control — Synthesized VFO, HFO, and BFO for stability and easy tuning.
Tuning — 100 Hz per step, 5 kHz per knob rotation. Pushbuttons provided for up/down tuning (rate is internally adjustable).
Operation — Split transmit/receive or transceive from either readout.
Synthesized Lock Indicator — Visual indication when the synthesizer is unlocked. Transmitter is disabled when the synthesizer is unlocked.
Frequency Stability — Less than 3 ppm drift from turn-on for first 15 minutes. Less than 3 ppm/hour drift after 15 minutes warm-up. Less than 20 ppm drift from 0°C to +40°C. (Single crystal-controlled 10 MHz frequency standard.)
Modes of Operation — LSB; USB; CW-Wide; CW-Medium (400 Hz filter); CW-Narrow (200 Hz filter); RTTY (LSB, 400 Hz filter).
Operating Temperature Range — 0°C to +40°C.
Speech Processing — Adjustable rf speech compressor.
IF Shift — Incremental plus and minus passband shift (−600, −400, −200, −100, 0, +100, +200, and +400 Hz).
Power Requirements* — 11 to 16 Vdc with a nominal current maximum of 25 amperes at 100 watts CW output. Receiver current is 2 amperes nominal.
Front Panel Connectors — Microphone, headphones.
Rear Panel Connectors & Control — Antenna (SO-239); Linear ALC In; Linear ALC Adjust; Low Power Enable; Spares (5); DC Power Input; CW Key Jack; External Transmit Audio In (2); Speaker Out; External Receiver Audio; T/R In; T/R Out; Mute; Mute (inverted); External Relay (linear); Optional RS-232 Computer interface.
Front Panel Meter — Receive: S units, Transmit (selectable: ALC, relative rf power, or speech compression).
Phone Patch Impedance — 4-ohm output to speaker, high impedance input to transmitter.
Available Accessories — 400 Hz CW filter; 200 Hz CW filter; Computer/terminal interface; AC power supply/speaker with built-in dual time 12/24-hour clock; Customer Service Manual.
Cabinet Dimensions — 6-1/8" high × 14" wide × 13-3/4" deep (15.6 × 35.6 × 34.9 cm).
Weight — 35 lbs. (15.9 kg).

Transmitter

RF Power Output — SSB: 100 watts PEP minimum. CW & RTTY: 100 watts mimimum.
Duty Cycle — 100 percent with appropriate automatic power output reduction by an internal thermal sensor. This reduction is determined by the time factor and the ambient temperature. The nominal parameters are as follows:

Ambient Temperature:	+25°C.
Supply Voltage:	+13.8 VDC.
Frequency:	14.1 MHz.
Mode:	CW key down, 100% duty cycle.

Example:

Power Output	**Time**
100 watts	0 min.
80 watts	3 min.
60 watts	10 min.
40 watts	Infinite

Load Impedance — 50 ohms.
VSWR — This Transceiver is stable at any VSWR and load impedance. The VSWR cutback circuitry guarantees at least 80 percent of rated power at any VSWR less than 2:1 and a minimum of 15 watts at any VSWR.
Transmitter Protection — Thermally protected. High VSWR cutback. Over-current protection.
Carrier Suppression — 50 dB down from a 100 watt, single-tone (1000 Hz) output.
Unwanted Sideband Suppression — 55 dB down from a 100 watt, single-tone (1000 Hz) output.
Harmonic Radiation — 50 dB down below 50 MHz; 65 dB down above 50 MHz.
Spurious Radiation — 50 dB down, except at 17 meters (40 dB down).
Third Order Distortion — 30 dB down from a 100-watt, PEP, two-tone output.
T/R Operation — SSB: *PTT or VOX. CW: Semi break-in.*
CW Sidetone — To speaker or headphones (700 Hz tone, adjustable level).
Microphone Input — High impedance (25 k ohm) with a rating of −55 dBm.

Receiver

Sensitivity — 0.3 μV for 10 dB (S + N)/N SSB on the 40 thru 10 meter bands; 0.5 μV on the 160 and 80 meter bands.
Selectivity — 2.1 kHz at 6 dB down; 5 kHz at 60 dB down.
With CW filters:
CWM: 400 Hz at 6 dB down; 1.5 kHz at 60 dB down.
CWN: 200 Hz at 6 dB down; 1 kHz at 60 dB down.
Overall Gain — Less than 1 microvolt for a .25 watt audio output.
Audio Output — 1.5 watts into 4 ohms at less than 10% THD.
AGC — Fast-attack with switch selectable Off, Fast, and Slow decay.
Intermodulation Distortion (20 kHz spacing) — −70 dB.
Image Rejection — −80 dB (except −65 dB on the 17 and 12 meter bands).
Second IF Rejection — −90dB.
First IF Rejection — −80 dB (except −60 dB on the 40 and 30 meter bands).
Internally Generated Spurious Signals — Generally below the noise level; all below 1 microvolt equivalent.
RIT — ±250 Hz.

table 2. SS-9000 Specifications.

none of them would keep me from standing in line to buy one. And if that sounds like an enthusiastic endorsement of the SS-9000, that's because it is!

At this time, final price is a bit up in the air. Heath is scheduled to begin shipping the SS-9000 in the first quarter of 1983. An introductory price of $2495 for the transceiver plus power supply is planned.

ham radio

safe power
for your low-noise
GaAs FET amplifier

Safeguard expensive GaAs FETS with this protective power supply

Without forward bias, a small-signal bipolar transistor won't do anything; without *back-bias*, a GaAs FET (Gallium Arsenide Field-Effect Transistor) may never do anything again! When power is first applied to a GaAs FET, it is important that the negative bias appears first, otherwise the transistor may go into saturation and destroy itself. Furthermore, when the supply is turned off, the negative bias voltage should not disappear until after the positive supply has run down; otherwise, the drain current may be excessively high long enough to destroy the transistor. A lack of appreciation of these subtleties may result in the demise of your expensive GaAs FET.

GaAs FETs can provide receiver front-end performance not otherwise available to most Amateurs and hobbyists, but they are usually quite expensive. Why not protect your investment with a power supply that has these important features? It's inexpensive insurance as well as good practice.

Because I frequently work with GaAs FETs, I take the necessary precautions when soldering them into a circuit. Assuming that the power supply for operating the circuit is properly designed, and in particular includes the necessary protective circuits, everything will be fine; but, if one day the negative-bias supply fails for some reason . . . no GaAs FET. A good indicator of potential trouble is a momentary kick in drain current when the device is turned on or turned off.

the supplies

Most experimenters find it convenient to use a sin-

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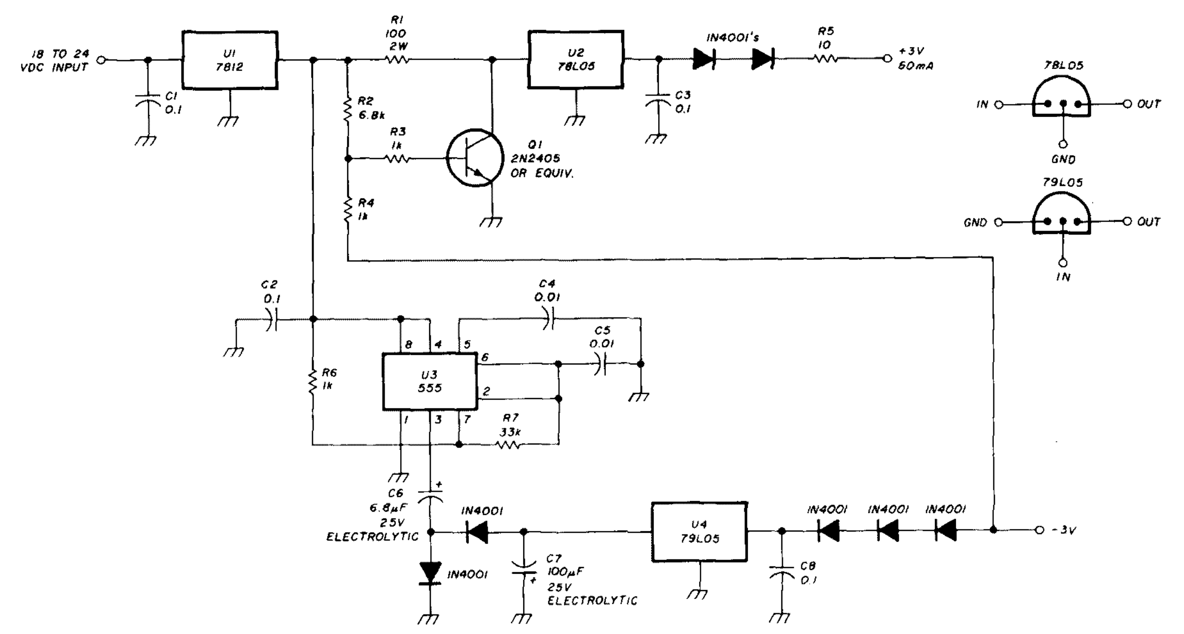

fig. 1. Safe power supply for GaAs FETs. Both positive and negative voltages are developed from a single 18 to 24 Vdc source. U3, a 555 timer, and C6 are connected to provide low-current negative-going dc pulses that are rectified and regulated. (C6 must be within 20 percent of 6.8 μF; 1N916 diodes may be substituted for the 1N4001s shown.) The R/C network of R1 and C2 delay the rise of the positive output voltage, and Q1 (a crowbar) cuts out the negative supply voltage if the positive voltage fails for any reason. This ensures that the negative voltage is always present first, and stays until the positive voltage disappears.

gle positive power supply rather than separate positive and negative supplies. An effective way to develop negative bias from a positive supply is through an inverter. A popular circuit employs a 555 timer with a rectifier and filter, such as the one described in the *Signetics Analog Data Manual*[1]. The potential hazard of this arrangement when used with GaAs FETs is that the negative supply voltage will build up slightly after the positive output voltage when the device is turned on. You need to delay the positive ramp by means of an R/C (resistor/capacitor) network.

The circuit diagram of the GaAs FET power supply is illustrated in **fig. 1**. Note that the R/C network consists of: the 2-watt 100-ohm resistor, R1; the 78L05 voltage regulator, U2; and the 0.1 μF output capacitor, C2. This allows the positive output voltage to build up at a fairly fast rate, perhaps to 63 percent of full voltage in 10 μs or less, depending on the GaAs FET drain current. How soon after dc power is applied does the negative bias appear? If a dual-trace oscilloscope is available, it can be used to display the relative timing between the negative and positive voltages when the device is turned on. More will be said about this later.

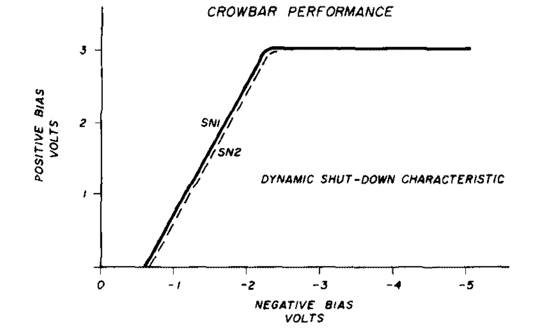

fig. 2. Dynamic characteristics of the crowbar under negative-bias short-circuit conditions.

When turned off, the charge stored in C3 (the output filter capacitor of the positive supply) will discharge harmlessly through the GaAs FET drain circuit, provided the negative bias voltage ramps down at a slower rate. (This is usually the case because the negative supply need only deliver current to one or two bias potentiometers usually between 5 and 10 kilohms each. In my application, it takes approxi-

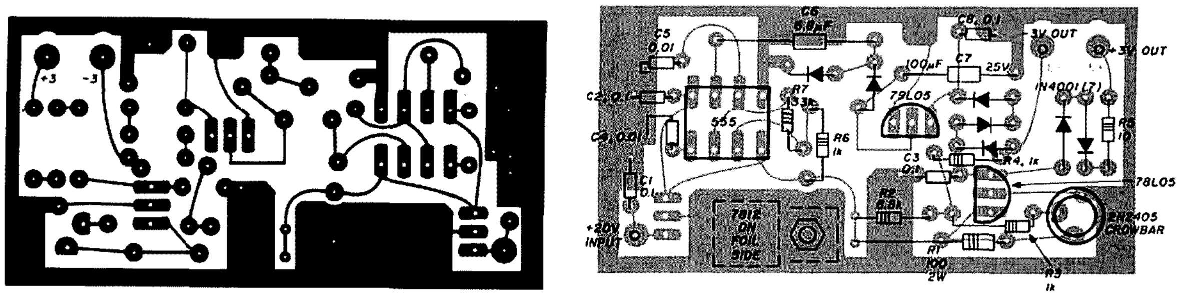

fig. 3. The power-supply board as designed by the author. *Fig. 3a* is the full-sized artwork of the foil side of the board; *fig. 3b* shows component placement from the other side.

mately 500 mS for the negative bias to decay to 37 percent of its initial level because of C7, the 100 μF capacitor at the input of U4, the 79L05 negative-voltage regulator.) At the same time, the positive output, which supplies current to a much smaller equivalent load resistance, ramps down very rapidly. This is a desirable condition.

the crowbar

What about the race between the positive and negative voltages that occurs at turn-on? And what about the catastrophic situation we talked about earlier that could result from a random failure of the negative supply? A crowbar can be used to protect against these disaster-causing events.

The crowbar consists of Q1, an NPN bipolar transistor capable of continuously dissipating the output of the positive supply. Normally this transistor is turned off, but if for any reason the negative supply should fail, the base bias of the crowbar becomes positive, turning the transistor on. A conducting transistor reduces the voltage at its collector to a fraction of a volt; as a result, the voltage available to the 78L05 is insufficient to turn it on, and the positive output voltage remains at zero.

The dynamic characteristics of the crowbar under negative-bias short circuit is such that, as the negative bias ramps down, the positive voltage also ramps down, as shown in **fig. 2**. (Even a short circuit occurs over some finite time interval.) Note that the positive voltage always lags behind the negative voltage.

connecting to the GaAs FET amp

It has been suggested that silicon diodes be placed in series with each power-supply output to any GaAs FET amplifier to protect against reverse voltage spikes. I do not recommend this; failure of such a diode in the negative lead would be catastrophic, even though the power supply would function normally. It may be desirable, however, to connect 3.9 volt Zener diodes between each power-supply output and ground, to protect against spikes or over-voltages. Failure of either of these diodes would not affect the protective ability of the crowbar and the R/C network, it would simply put the system out of operation.

Before connecting your GaAs FET amplifier to the power supply, substitute a resistive load and connect a voltmeter to the supply's positive output terminal. Then short-circuit the negative supply terminal and note that the +3 volt output goes to zero.

a testimonial

I have used the circuit in **fig. 1** for my earth station LNA (low-noise amp) for well over a year now without the loss of a single GaAs FET transistor, in spite of summer's heat, winter's cold, rain, sleet, ice, and snow; power-line fluctuations and loss, and intense lightning. I sleep better at night knowing that if the 555 timer or any of the other components in the negative supply should fail, the positive supply will shut itself off. In fact, any time the positive voltage gets ahead of the negative voltage for any reason, the crowbar holds off the positive voltage until it is safe to proceed. This includes when the device is being turned on or off. Thus, the crowbar protects against any race the positive voltage would otherwise win.

If you would prefer not to fabricate your own printed-circuit board from the artwork in **fig. 3**, boards are available from the author for $7.90 each, including postage and handling. These boards are made from 1/16-inch thick epoxy fiberglass (G-10) and they come solder plated and drilled.

reference

1. *Signetics Analog Data Manual*, 1977, fig. 6-26a, page 729.

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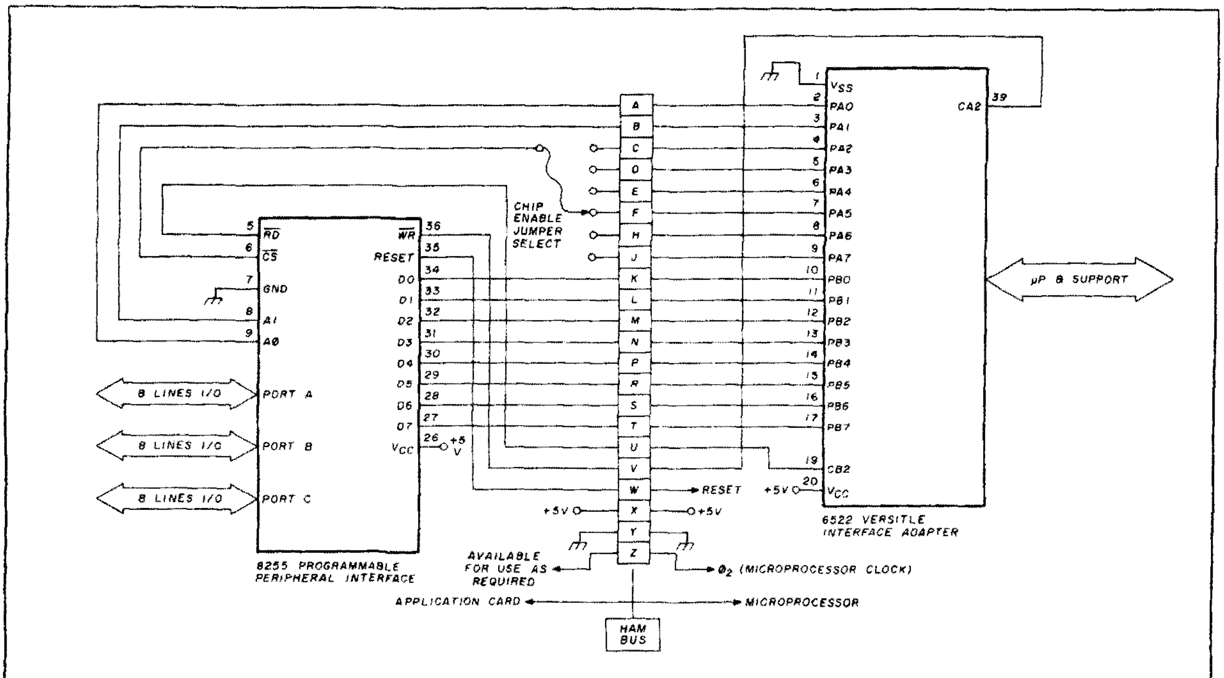

fig. 1. Basic application card schematic.

an intelligent ham gear controller part 2

Programming, communication, and display application card for the ham gear controller

Part 1 of this article detailed the controller system and basic circuit card construction. This, the second part, will cover elementary programming, communication with external devices, and describe an all-purpose, eight-digit display application card.

The controller is not intended to be a computer; the microprocessor is a 6502 chip with 1K (1024) bytes of static RAM and 2K (2048) bytes of EPROM. All communications with external devices are made

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table 1. Microprocessor instruction groups for control, output and input of application cards.

instruction	6502 data bus	program address	details
Initialize Application Card			
Set direction of VIA port A	$FF	$6003	Port A of VIA is set to OUTPUT
Set direction of VIA port B	$FF	$6002	Port B of VIA is set to OUTPUT
Select PPI and control word	(ADDR)	$600F	X-register of 6502 to contain ADDR, WRITES into VIA Port A and latches HAM BUS lines PA0-PA7 to ADDR
Set PPI port control	(CTRL)	$6000	Accumulator of 6502 to contain CTRL, WRITES into VIA Port B and latches HAM BUS lines PB0-PB7 to CTRL
Activate PPI from HAM BUS	$EC	$600C	HAM BUS CA2 = 0, CB2 = 1; PPI accepts control word on D0-D7 from PB0-PB7, sets port directions in PPI
Deactivate PPI from HAM BUS	$FF	$600C	HAM BUS CA2 = 1, CB2 = 1; PPI D0-D7 go to high-impedance
WRITE output through PPI			
Set direction of VIA port A	$FF	$6003	Port A of VIA is set to OUTPUT
Set direction of VIA port B	$FF	$6002	Port B of VIA is set to OUTPUT
Select PPI	(ADDR)	$600F	X-register of 6502 to contain ADDR, WRITES ADDR into Port A of VIA, latching HAM BUS lines PA0-PA7.
Set up DATA for OUTPUT	(DATA)	$6000	Accumulator of 6502 to contain DATA, WRITES DATA into Port B of VIA, latching HAM BUS lines PB0-PB7
Activate PPI	$EC	$600C	HAM BUS CA2 = 0, CB2 = 1; PPI accepts DATA on D0-D7, transmits it to external device.
Deactivate PPI from HAM BUS	$FF	$600C	HAM BUS CA2 = 1, CB2 = 1; PPI D0-D7 go to high impedance
READ input through PPI			
Set direction of VIA port A	$FF	$6003	Port A of VIA is set to OUTPUT
Set direction of VIA port B	$00	$6002	Port B of VIA is set to INPUT
Select PPI	(ADDR)	$600F	X-register of 6502 to contain ADDR, WRITES ADDR into Port A of VIA, latching HAM BUS lines PA0-PA7
Activate PPI	$CE	$600C	HAM BUS CA2 = 1, CB2 = 0; PPI transmits external data through D0-D7 to HAM BUS PB0-PB7, latching input in Port B
Read external DATA	(DATA)	$6000	Accumulator of 6502 loaded from VIA Port B; only read command of 6502 associated directly with I/O.
Deactivate PPI from HAM BUS	$FF	$600C	HAM BUS CA2 = 1, CB2 = 1; PPI D0-D7 go to high impedance. Accumulator retains DATA if $FF sent from X-register.

table 2. Detailed bit assignments of PPI for ADDR data in table 1.

PPI function	selected bit PA7 to PA2	HAM BUS bit states PA1	PA0	CB2	CA2
READ Port A data into HAM BUS	0	0	0	0	1
READ Port B data into HAM BUS	0	0	1	0	1
READ Port C data into HAM BUS	0	1	0	0	1
WRITE HAM BUS data to Port A	0	0	0	1	0
WRITE HAM BUS data to Port B	0	0	1	1	0
WRITE HAM BUS data to Port C	0	1	0	1	0
WRITE HAM BUS data into PPI to select port direction (Control Word)	0	1	1	1	0
Disable PPI data bus D0-D7 by setting high-impedance state	0	x	x	1	1
-OR-	1	x	x	x	x
Illegal state, don't use in program	0	1	1	0	1

Note: Selected bit is jumpered from PPI $\overline{CS}$ pin 6 to HAM BUS connector; *all other bits* in address must be logic *one*.
"x" is 'don't-care' condition, either 1 or 0.

by a 6522 Versatile Interface Adapter (VIA) located on the processor card through eighteen input/output (I/O) lines of the system's HAM BUS. An 8255 Programmable Peripheral Interface (PPI) on each application card links the HAM BUS with external circuitry.

The emphasis in this article will be placed on VIA and PPI interaction with the microprocessor, plus specific program operation with the eight-digit application card. The builder needs some knowledge of microprocessor or computer action. Hexadecimal (hex) notation is indicated by the dollar-sign prefix convention.

the VIA connection

Fig. 1 shows the basic application card connection to the HAM BUS and VIA on the microprocessor card. Port A of the VIA is always used to address a PPI. Port B of the VIA is bidirectional, used primarily for handling external circuit data. Only two of the four control lines are connected to the HAM BUS; CA2 and CB2 are output ports used to control the read and write functions of the PPI.

VIA function is set by both address and data busses within the microprocessor card. The four least-significant bits of the processor address bus are connected to VIA register-select pins RS0 to RS3; these are major VIA function lines. The processor data bus handles sub-functions.

To facilitate your understanding of the operation of the VIA, **table 1** lists the three major instruction groups for basic I/O handling of application cards. For more detail on VIA capabilities, the reader should study data sheets or tutorials on support devices.

communication

An 8255 has three modes of operation; Mode 0, or basic I/O is assumed.[1] Each PPI must be initialized for mode and port usage through the first instruction group shown in **table 1**.

The first two instructions set the VIA ports to transfer output from the 6502 to the HAM BUS; the 6502 data bus ADDR (address) state is detailed in **table 2**. Port arrangement in a PPI is controlled by writing a control word into pins D0 to D7. Both PA1 and PA0 of the HAM BUS must be set at logic 1 to select a control word. Only one line of PA7 to PA2 may be logic 0 to address a particular PPI (all others logic 1), because of the simplified addressing jumper on each application card.

Writing anything to VIA addresses $6000 or $600F will latch the 6502 data bus into the appropriate VIA output port. The fourth initialization instruction writes CTRL into VIA port B, to prepare for the PPI port selected for use. **Table 3** lists the 6502 data bus states for the different PPI port directions.

A PPI is activated when VIA control lines CB2 and CA2 are set to opposite states (**table 2**). Once a WRITE mode is established, the PPI is selected and the control word is loaded into it. PPI port direction

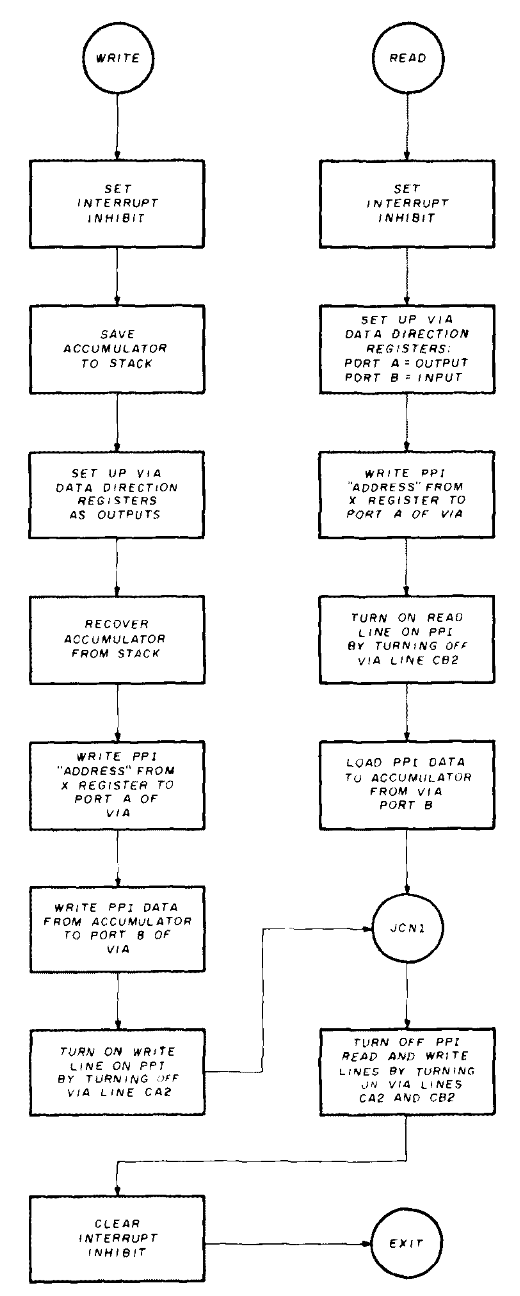

fig. 2. Program flow for writing and reading external circuitry through a PPI.

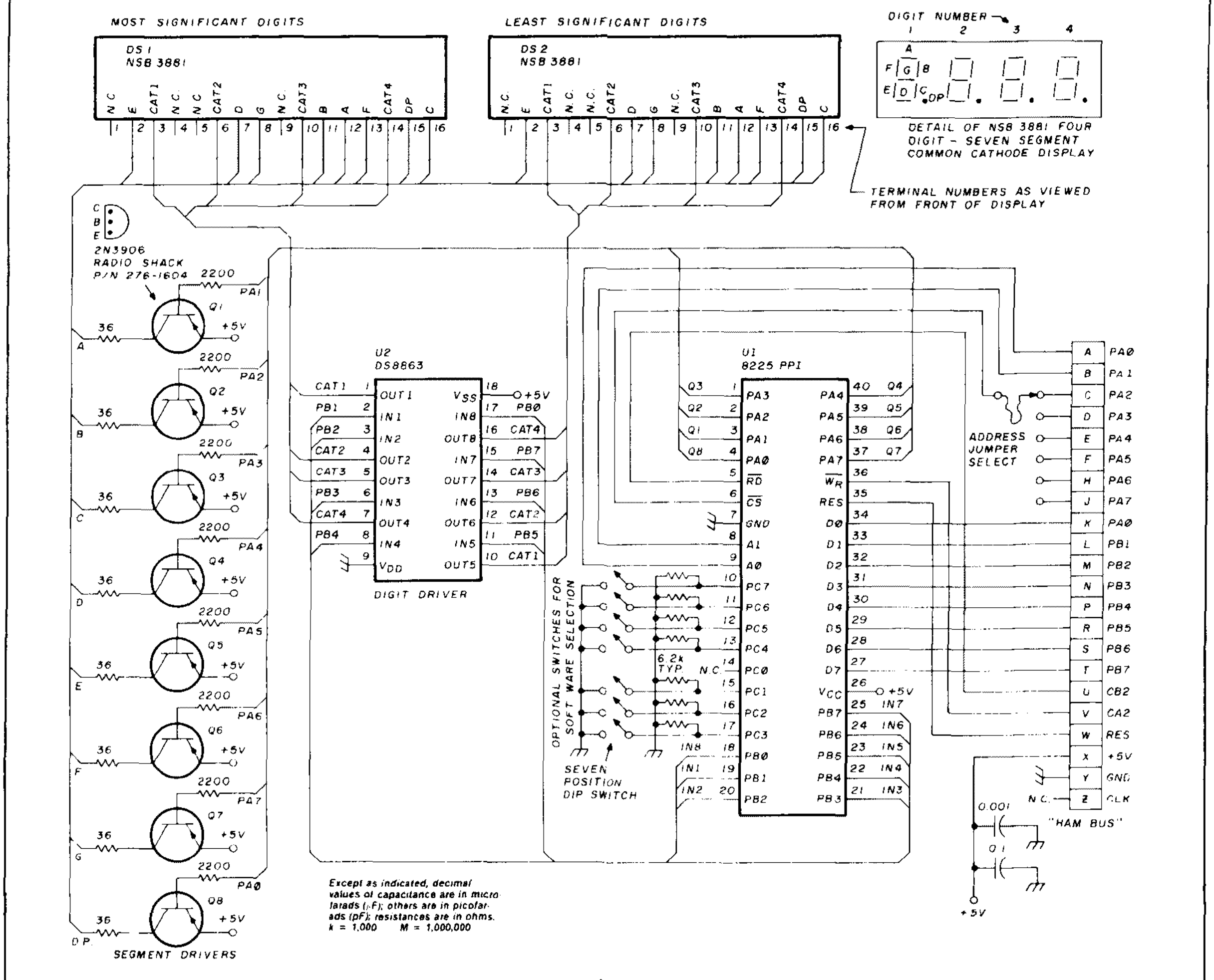

fig. 3. Eight-digit display application card.

and mode are then configured for communication.

The final instruction deactivates all 8255 data lines (D0-D7) by placing them in a high-impedance state. Any PPI port set for an output will hold that data, latched internally. Deactivating the 8255 data lines will minimize VIA loading.

external communications

Writing to and reading from external devices is done through the last two groups of instructions listed in **table 1**. To write data you must choose one of the three bit patterns shown in **table 3**; CB2 and CA2 remain in the state they were in upon initialization. DATA is the eight-bit word sent through the PPI to the external circuitry.

A READ instruction (**table 1**) is organized differently. The address must be one of the three READ conditions found in **table 2**. The PPI is activated immediately after a PPI READ. This sequence allows the PPI to send its port data into the HAM BUS, automatically latching that data into VIA port B. The 6502 is then able to address the VIA to read the data in port B into memory.

WRITE and READ instruction sequences are shown in **fig. 2**. A WRITE sequence starts with the PPI address in the 6502 X-register and the output data (or control word) in the accumulator. A READ sequence also starts with the PPI address in the X-register, but ends with external data input loaded in the accumulator.

This explanation, illustrating the HAM BUS operation, occupies more space than the routines occupy in memory. The READ and WRITE sequences are housekeeping subroutines requiring only fifty-three bytes of program memory.

table 3. Selection matrix of PPI port direction. CTRL data in table 1.

port A	port B	port C	hex word on HAM BUS PB0-PB7
output	output	output	$80
output	output	input	$89
output	input	output	$82
output	input	input	$8B
input	output	output	$90
input	output	input	$99
input	input	output	$92
input	input	input	$9B

an eight-digit display application card

A full explanation of application cards and supporting software is too lengthy to give here; the digit display in figs. 3 and 4 is an example, however. Eight digits will show one Hertz on a 30-MHz frequency display. More or fewer digits may be used as desired.

The display is multiplexed one digit at a time by software. Scanning is at 500 Hz, fast enough to appear continuous. I chose four-digit, seven-segment units for ease of construction; individual, non-multiplexed digits can also be used.

The display is bright enough to be seen in high-level indoor lighting; the segment currents peak at about 55 mA. Higher peak currents could be used if they don't exceed the 8863 digit-cathode driver's ratings. Another risk occurs at high current: an inadvertent scanning stop may burn out individual segments.

When I finished the display, the eight lines of PPI port C were left unused. Rather than waste those lines, an eight-pole DIP switch could be added to

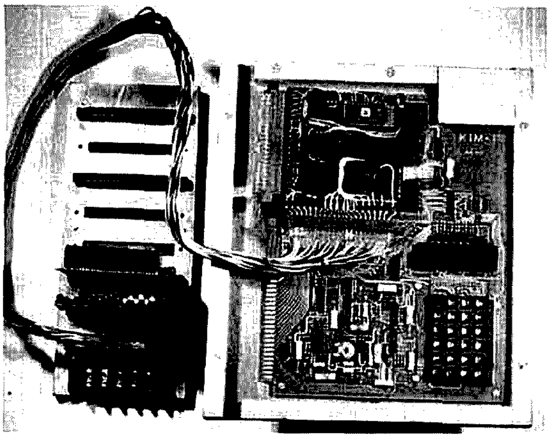

fig. 4. Eight-digit display card, component side.

table 4. Display card character coding and multiplexed scanning control assignments.

character displayed	HAM BUS hex byte at PPI port A
0	$81
1	$F3
2	$49
3	$61
4	$33
5	$25
6	$05
7	$F1
8	$01
9	$21
A	$11
B	$07
C	$8D
D	$43
E	$0D
F	$1D

Note: Subtract 1 for right-hand decimal point.

segment control

segment	PPI port line
A	PA1
B	PA2
C	PA3
D	PA4
E	PA5
F	PA6
G	PA7
d.p.	PA0

digit control

digit	PPI port line
1	PB1
2	PB2
3	PB3
4	PB4
5	PB5
6	PB6
7	PB7
8*	PB0

*Least-significant digit.

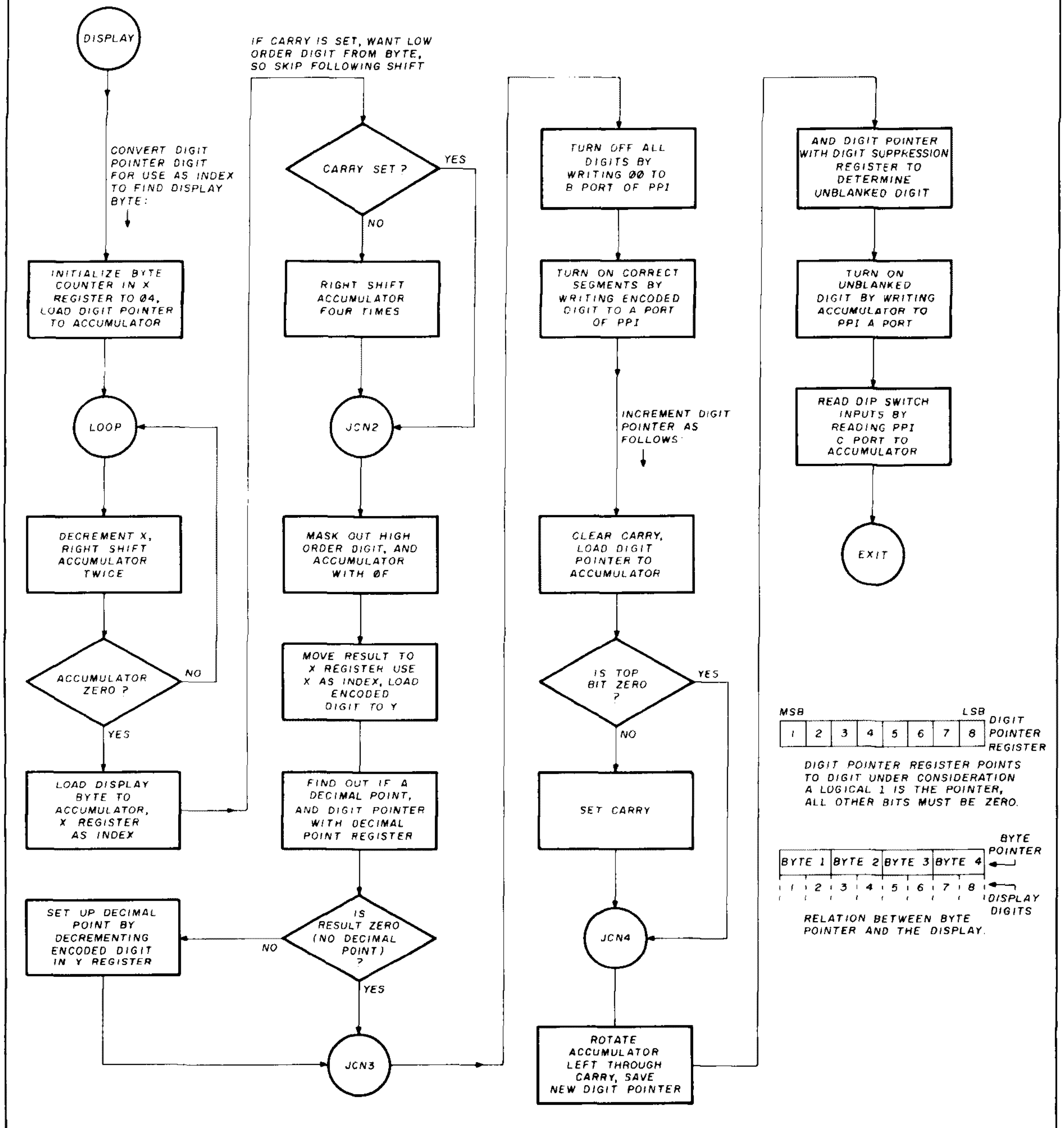

fig. 5. Display card program flow with decimal-point register bit locations.

select software options. The eight lines of port C could then be used for many purposes with appropriate software changes.

Fig. 5 shows the program flow of the display card software. Digit encoding and multiplex scanning is handled by the microprocessor. Software control makes it possible to display decimal or hex numbers, control blanking, and locate decimal points without hardware changes. Display card character coding and multiplexed scanning control assignments are seen in **Table 4**.

My display routine requires seven bytes of RAM: four bytes for display information, one byte as a digit pointer, one as a decimal-point register, and one byte for digit suppression (blanking). The EPROM contains sixteen bytes devoted to an encoded digit look-up

table. Total EPROM space is only 115 bytes, including the look-up table and initialization of the digit pointer register. The latter operation requires setting only one bit of the pointer register to logic 1.

start-up and test

Trace and ring-out all wiring before installing the ICs, then begin with the simulator card alone. Connect the simulator and use +5 Vdc from the microprocessor development system for the initial testing only. Install ICs only when the wiring checks out correctly. *Caution:* many ICs are static sensitive — be careful how you handle them!

Power up the development system and simulator. Verify that the EPROM can be read. The 6522 counters will run freely at clock frequency after reset. Check them out by observing the operation at addresses $6004 and $6007.

Next, shut off the power, remove the development system +5 Vdc temporary connection, and connect the mother board with only the bus status indicator card installed. Turn on the development system and the controller power supply. Manually check the HAM BUS lines by development system control. Check all 6522 functions.

Write a demonstration program for the microprocessor card. I chose to use a simple routine with the display card that counted in hex and displayed the result. Then burn the completed, debugged program into the EPROM[2].

Finally, install the microprocessor card and disconnect the controller from the development system. Testing the microprocessor is made easier by including the display card switches in the demonstration program.

I encountered two glitches during checkout. Turning on and off the fluorescent lights over my work area caused panic in the simulator and development system but no problem with the controller itself. This may be caused by line noise getting into the development system.

The second problem I encountered was intermittent edge connector contacts. I cured that by cleaning contact surfaces with a typewriter eraser (or try fine sandpaper).

Information on program documentation and burned EPROMs may be obtained by sending the author a self-addressed, stamped envelope.

references

1. *Peripheral Design Handbook,* August, 1981, Intel Corporation, 3065 Bowers Avenue, Santa Clara, California 95051.
2. C.A. Eubanks, N3CA, "2716 EPROM Programmer," *ham radio,* April, 1982, pages 32-36.

ham radio

low-noise preamplifiers with good impedance match

Taking advantage of hybrid-coupled amplifier techniques

There are several ways to make your receiver or preamplifier match the transmission-line impedance and at the same time obtain a near-optimum noise figure.

At microwave frequencies, an isolator or terminated circulator (a non-reciprocal device — passing a signal in one direction only) is an easy fix. The insertion loss (which adds directly to the noise figure) and cost are drawbacks. A low noise figure and good match may be achieved with feedback circuitry up to a few hundred MHz. Some amplifiers use the Miller effect to reduce the input impedance without changing the noise figure. Added emitter (drain) inductance does the same thing, at some risk of parasitic oscillation. Other circuits use ferrite transformers to introduce feedback. The resulting reduction in gain and the effect upon the amplifier's reverse isolation may not be important enough to matter at frequencies up to 70 MHz or so.

the hybrid-coupled amplifier

Above 100 MHz, there is another practical solution: two identical amplifiers between two quadrature hybrid couplers, one at input and the other at output. Because of the characteristics of a 90-degree hybrid, identical mismatches at the two amplifier inputs add up to a low (1.2:1 or less) input VSWR. The noise figure is increased only by the loss through the hybrid; the gain is the same, and the permissible input signal is doubled. Networks may be inserted between the hybrid outputs and the amplifier base leads to improve the noise figure.

Equalizing networks can be put on the amplifier outputs to obtain flat gain over a two-to-one useful frequency range, and it is even practical to add up to four shunt PIN diodes for gain control, as shown in **fig. 1**, without adversely affecting the impedance match.

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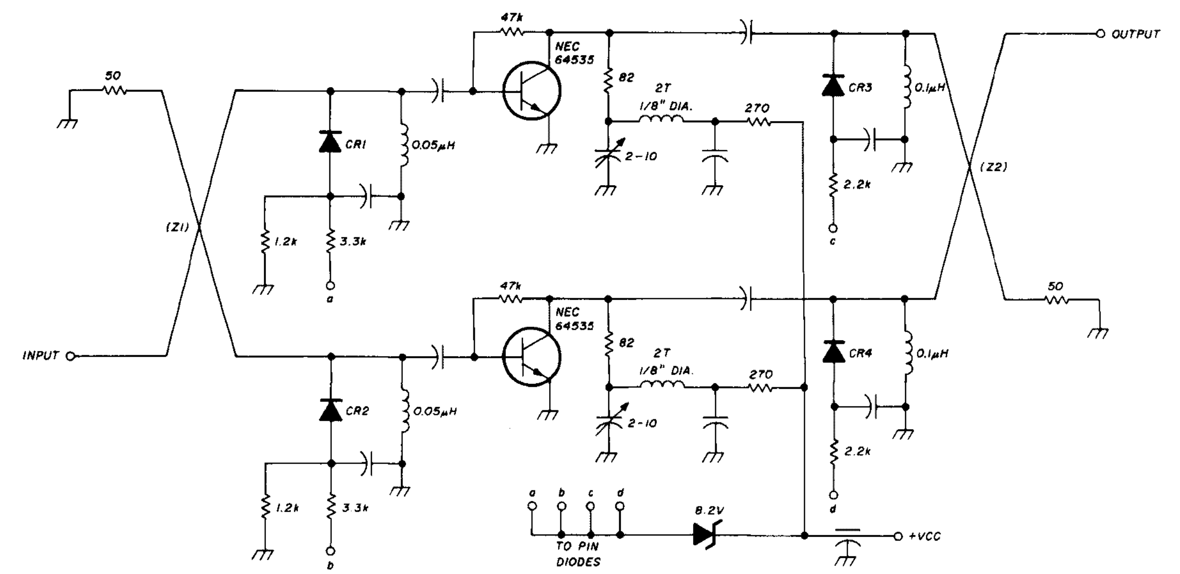


fig. 1. A gain-controlled amplifier for 200-400 MHz. Gain at V_{cc} = 7 volts is 20 dB; at V_{cc} = 15 volts is 6 dB. All unmarked bypass capacitors are 0.001 μF chips. CR1 through CR4 are PIN diodes. Z1 and Z2 are hybrids constructed of Wireline® as described in the text.

The hybrid-coupled amplifier was described in print many years ago.[1] The units I constructed (for 200-400, 300-600, 600-1300, and 900-1500 MHz) all have good noise figure, good match, and are stable and well-behaved. I used the NEC 64535 (about $12 — relatively as cheap as my first 6AC7 in 1941) because it suits 50-ohm circuits very well, and has excellent gain at low-noise operating conditions. I was able to get 12 dB gain at 1296 MHz, 18 dB at 432 MHz, and 20 dB at 220 MHz, from a single stage. The amplifiers can be made flat in response (plus or minus 0.5 dB) over a two-to-one frequency range without much trouble, and it was easy to get them working properly. The results are worth the extra parts required for twin amplifiers.

VHF quadrature hybrids are commercially available from many sources. Microwave Associates, Merrimac, and Anaren sell a flat, rectangular package with solder tabs. Sage Laboratories, Inc., for whom I developed the amplifiers, makes Wireline®, a cable designed so that any length constitutes a directional coupler, and a quarter-wavelength (× 0.65) is a 3-dB hybrid. It has two wires embedded in a Teflon-dielectric coaxial cable. I used the copper-jacketed type HC, and wound the lengths on a mandrel to get coils which would easily fit in the amplifier enclosure. The hybrid assemblies are stripped and soldered in place on the glass-Teflon pc board. This required only dots of solder on the copper jacket at each end. **Fig. 2** shows an assembly for 200 to 400 MHz (16 cm).

impedances

Like many other microwave transistors operating in the UHF region, the NEC 64535 requires a particular value of base-source impedance for each value of collector current and frequency to obtain the best

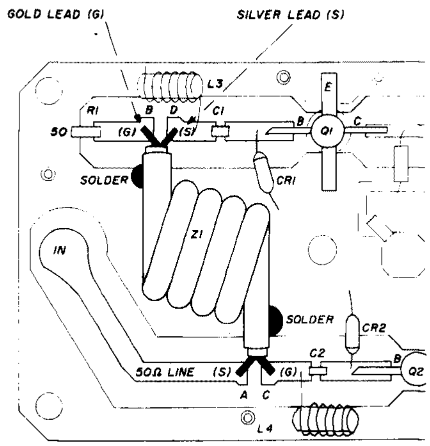


fig. 2. Construction and mounting details for Z1 and other components. Note the connection points for the gold-colored (G) and silver-colored (S) leads. The copper shield of the Wireline® is tack-soldered to the circuit-board foil at each end. The diode (CR1,CR2) position is that used in *fig. 4*. L4, like L3, goes from terminal C to ground.

possible noise figure. The proper value, if known, could be obtained by some kind of a pi- or L-type matching network. For a wide band of frequencies, things could get complicated. In general, matching networks have a bit of loss associated with them. I chose to put either a series or a shunt coil at the output of the hybrid, since one or the other can be adjusted to come close to what's needed.

The Smith chart in **fig. 3** shows several sets of manufacturers' data and the locus of the two possible curves: 50 plus $j\omega L$ and 50 in shunt with $j\omega L$ (where $\omega = 2\pi F$). Neither of these is quite on target, but I found that by juggling current and adjusting the coil, I could find a best spot for either circuit, and they measured close to the same noise figure. The shunt inductor has a few minor advantages, especially for a wide-band amplifier. The inductor value probably should be tweaked at or near the high end of the band.

theory of operation

The incoming signal is split in half and goes to each of the two transistors. The signal-to-noise ratio in each transistor is three decibels below what it would be in a single amplifier. However, it is increased 6 dB when the correlated signals add at the output, while the thermal noise from the input termination is combined and fed into the output termination. This works very well over the octave range. If there were a short or open at the connectors, the amplifier would see a maximum 3:1 VSWR because of the terminated hybrids. The input match is good so

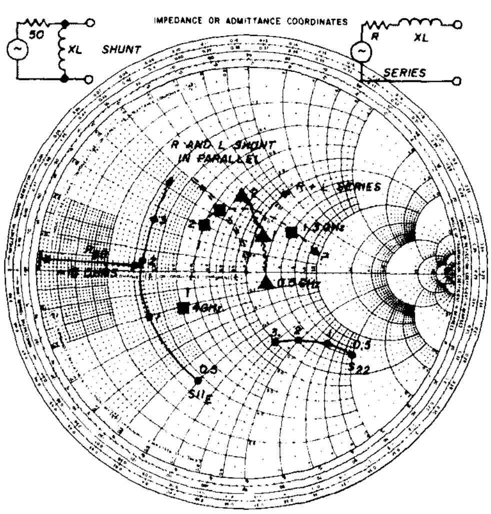


fig. 3. Manufacturers' optimum-source-impedance data plots shown are for one current value. Lower frequency or lower I_c produce higher Zs.

long as the two amplifiers are the same and are the same distance from the hybrid output terminals. Even out-of-band (less than half center-frequency or near twice center-frequency), where the hybrids aren't coupling, things are stable because one end of each amplifier is hooked to a 50-ohm resistor.

At 432 MHz, the amplifier has approximately 18 dB forward gain and 26 dB back isolation when load and source are matched. Inside, at 860 MHz, the forward gain is about 14 dB and the back isolation 24 dB, so things are still stable.

Fig. 4 shows the schematic of the 432 MHz preamplifier. The simple biasing method is made idiot-proof by the Zener diode, but the diode should be picked so it doesn't draw any current under normal operation. Its function is to protect against excess or reversed supply voltage. My design value for an NEC 64535 is 7 volts at 7 mA, so a 9.1 volt, 5-percent diode will do the job. Because the transistor is fed from a voltage twice its operating voltage, any change in current drawn will reduce the collector dissipation. The base-bias resistor can be hooked directly from base to collector, or to the bottom end of the collector choke, as is convenient. Its value may be different for different transistors: if the collector voltage is low, increase the value of the base-bias resistor. The Schottky diode from base to emitter is for protection from transmitter leakage. I wasn't able to measure a difference in noise figure after I added these diodes.

The inductances for impedance matching (L1, 2, 3, and 4), were constructed of No. 28 bus wire, either wound on a 2-56 nylon screw or self-supporting. In one case I tried a commercially made molded choke, and it was worse than nothing — its losses made the noise figure 0.6 dB worse than the air-wound (shunt) inductor.

The 33-ohm resistor with a two-turn pigtail coil is the (adjustable) gain-flattening device. Slightly more gain can be obtained if the coil is replaced by an LC circuit resonated at the high end of the band (550 MHz in this case), and the resistor can be at the hot end if desired (as shown in **fig. 1**).

A set-up for feeding in the supply voltage by way of the output coax is shown. If it isn't needed, omit L7 and L8 and put a bit of foil in place of the 15-pF capacitor. A 1N4001 is preferred as a voltage-feed diode because it is a poor rf rectifier.

construction

The circuit board is fairly simple. The two transistors are set in microstrip lines about 0.787 inch (2 cm) apart. Line widths for the 0.031 inch (0.079 cm) Teflon-fiberglass board (two sides copper) are equal to about three board thicknesses for 50 ohms. The chip capacitors are 0.05 × 0.1 inch (0.127 × 0.254 cm),

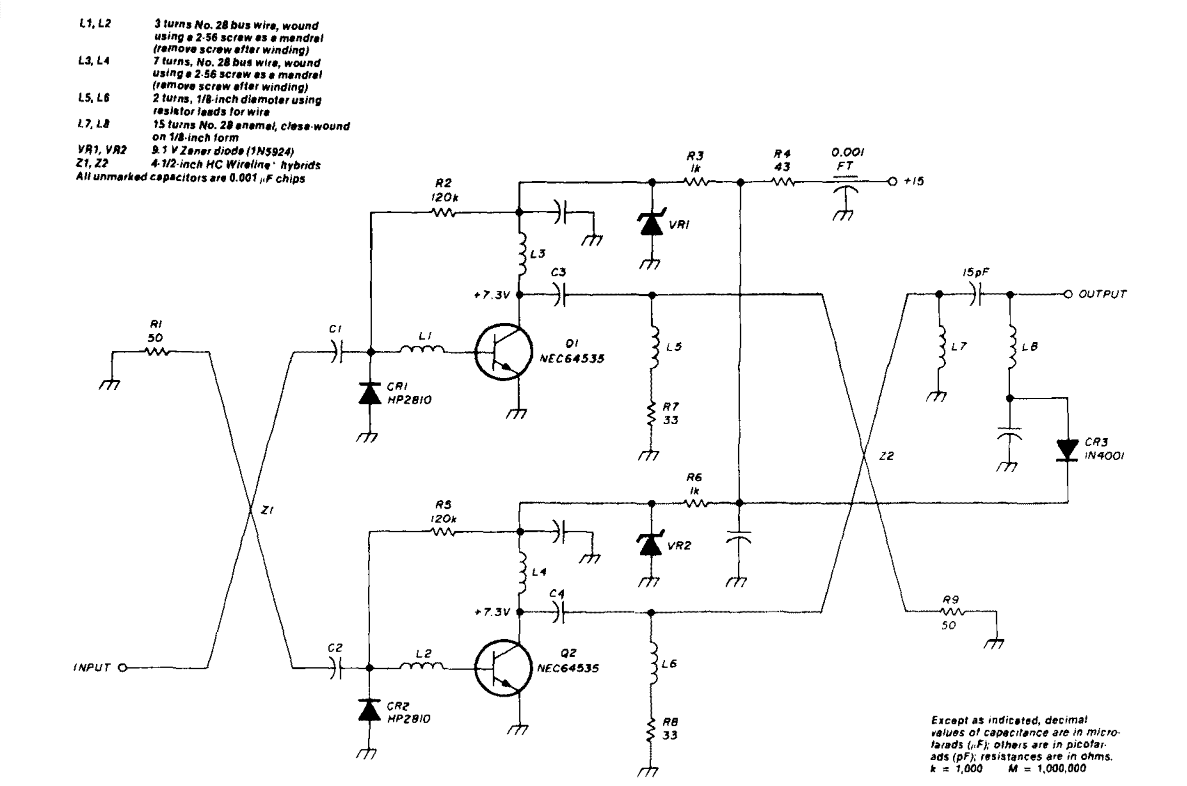


fig. 4. Schematic diagram of the 432-MHz amplifier. Best noise figure was obtained at 4 mA with a 9-volt supply. Gain is approximately 16 dB.

as are the 50-ohm chip resistors at the hybrids. I use 1000 pF chips partly because they are physically stronger than low values, and partly because they help discourage low-frequency parasitics (1 to 50 MHz). Eyelets are used as bonds from the top to bottom ground plane, and foil soldered around the edges near the input and output helps keep the top ground plane cold for rf.

The resistors and diodes are soldered to the flat copper surface. The chips are laid across gaps and soldered in place by putting the iron against the copper and letting the heat flow to the chip as the solder is applied at the junction.

mounting the transistor

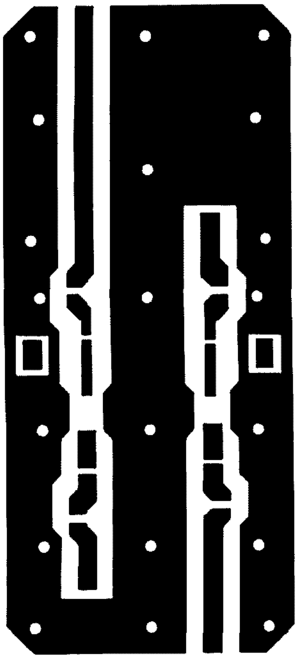
Since these transistors work best (at least at 1296 and below) with a bit of inductance in both base and collector leads, I put a small bend or loop in the leads (don't cut them short) before soldering them to the microstrip lines. The emitter leads lay flat on the copper, but there's no need to solder them close to the transistor body. They can be easy to change and still work their best. The leads help cool the package, but 50 milliwatts isn't much heat. The real problem is in the silicon: the chip is 0.3 mm square.

forming the Wireline® hybrids

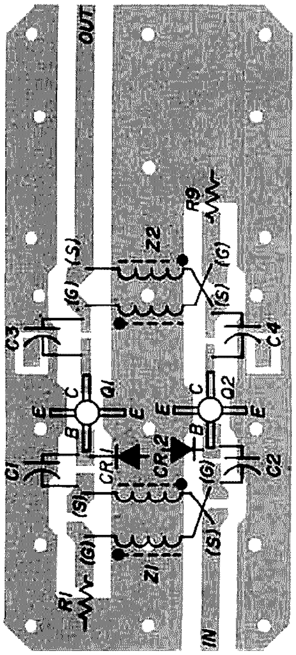
Type HC Wireline® can be coiled on a 5-mm rod if need be. The formula for length in inches is 1900 divided by F in MHz; 4.5 inches for 432. I used about 9 mm diameter (3/8 inch). Start with a piece 6 or 7 inches long, mark the length with paint or ink, then bend it by hand around the rod until the marked ends come out at the right places. Score with razor blade and crack the shield, then use diagonal cutters to cut the cable about a quarter inch farther out. Pull off the sheath and very *carefully strip* the insulation with a sharp blade — don't nick the little inner wires.

One conductor has gold insulation on it which will have to be removed to solder it to the wire. The sheath can be soldered to the ground plane at the ends, as the Teflon insulation doesn't melt easily. Keep the end leads very short — the end of the sheath should come right out to the striplines (see **fig. 2**).

The circuit board can be mounted inside a metal



Full-sized artwork for the quadrature-coupled amplifier. Double-sided glass-Teflon pc board is used. The dark areas are unetched copper. Top and bottom ground planes are bonded together by eyelets through the board and copper foil around the edges.



Component placement of the amplifier. Bo sure to observe the polarity of the windings in the hybrids Z1 and Z2. Chip capacitors and resistors are used to obtain low-inductance paths.

box with six or seven screws to hold it flat against the bottom. The box should be no wider than the board (4 cm) for best stability. Input and output connectors should connect directly to the 50-ohm microstrip, mounted either at right angles to the board with the pins laid on the strip conductors, or mounted through the bottom of the box so the contact pins come up through holes in the board to the conductors.

The 50-ohm terminating resistors are either chip type (film with solderable ends on a piece of ceramic, 0.050 × 0.100 inches, or 0.1270 × 0.254 cm), or a pair of 100-ohm 1/8-watt resistors with short leads and ends spread apart, placed flat on the board.

checking operation

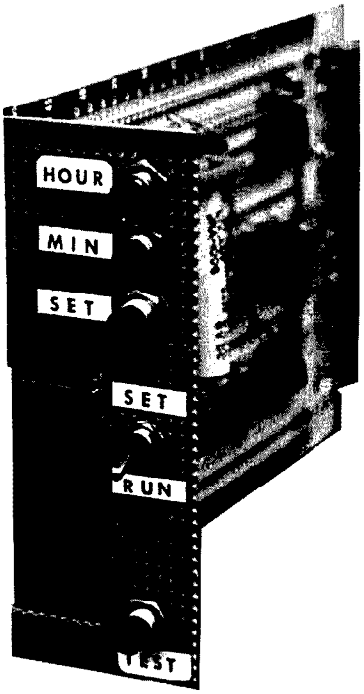
The biasing circuits permit you to short one or the other base to ground while listening to a signal. The signal-to-noise ratio should get slightly worse, but the gain shouldn't change much more than 6 dB as one transistor at a time is turned off. The first tests are to check voltages and currents (to make sure the bias is on target and that the various diodes are installed the right way). The characteristics are measurable with a sweep generator and a noise-figure set-up, but amplifier *input* impedance usually can't be checked because the test set (with the possible exception of the HP8505) usually fires too strong a signal into the amplifier.

You can use a bridge, provided it doesn't have a detector built in, in conjunction with a signal generator and a sensitive receiver. You can use a directional coupler, but it helps if the generator output goes into the coupled output and the detector is on the main line, as the signal fed to the amplifier will be less that way, especially if it's a 10- or 20-dB coupler. A slotted line is another possibility, but again use it reversed, with the signal fed in by way of the probe, and the detector on the far end of the line (the detector level will be less than a microwatt). If the amplifier gets more than about ten microwatts (minus 20 dBm) there will be a change in its input impedance, making the measurement pointless. If the amplifier has higher gain, it makes sense to operate at even lower signal levels.

referencce

1. R.S. Engelbrecht, and K. Kurokawa, "A Wide-Band, Low-Noise, L-Band Balanced Transistor Amplifier," *Proceedings of the IEEE*, March, 1965, page 237.

ham radio



synthesized time identifier for your repeater

The membership of Woodbridge Wireless, Inc., decided that the club repeater, WB4FQR, should have an automatic method for recording the time after termination of an autopatch. Members without LED watches often found it difficult, if not dangerous, while driving after dusk, to hold a microphone and refer to their watch for the time. The project was referred to our technical committee, with the suggestion that the time should be in voice with a cost less than $150.

Synchronized tapes were ruled out for two reasons. First, our repeater is located in an unheated metal building under a water tower, which could cause tape problems during cold months. Second, obtaining the tape system was too costly. A synthesized voice for the time function was decided upon, and the membership was in concurrence.

By **Douglas Phelps, Jr., WA4GUA**, 2912 Wren Court, Woodbridge, Virginia 22191

available hardware

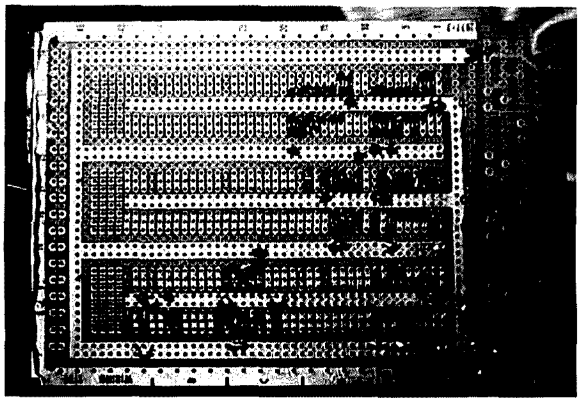
Sharp™ makes a synthesized voice clock known as "Talking Time." It is the size of a pack of cigarettes and sells for $80.00. Pressing a button on top of the clock controls the synthesized, voiced time signal.

Using Sharp's voice clock, a Vector™ prototype board and a few integrated circuits, the time function was incorporated into our repeater for $105. The time function was designed to be activated by the pound (#) button on a Touchtone™ pad. This provided easy access to the time function logging of the correct time at the end of an autopatch transmission.

The clock monitors the COR line in the repeater so that the time will not be transmitted over the air until the sending unit unkeys the microphone. A disable circuit was built for use with repeaters with remote-control capability — a feature that turns the clock off at any given moment.

circuit description

U5 (fig. 1) is a type-D flip-flop used as a memory for the decoded pound (#) signal. The D input of U5 is high when the clock is enabled. The flip-flop is normally reset, providing a low signal on Q output. The Q output will go high when the clock input goes high and will remain high until reset. Inverter C of U3 ensures that the logic level at pin 11 of U5 is normally low and goes high when a pound (#) signal is detected. Inverter B of U3 ensures that the logic level at pin 12 of NAND gate A goes low when a receive carrier is detected (COR active). Inverter A ensures that the logic level at the D input of U5 is high for enable and low for disable. (These inverters may be omitted to match other repeaters.)



Circuit is assembled on a standard Vector™ 44-pin prototype board. Clock is mounted in front with a piece of phenolic perfboard for a front panel.

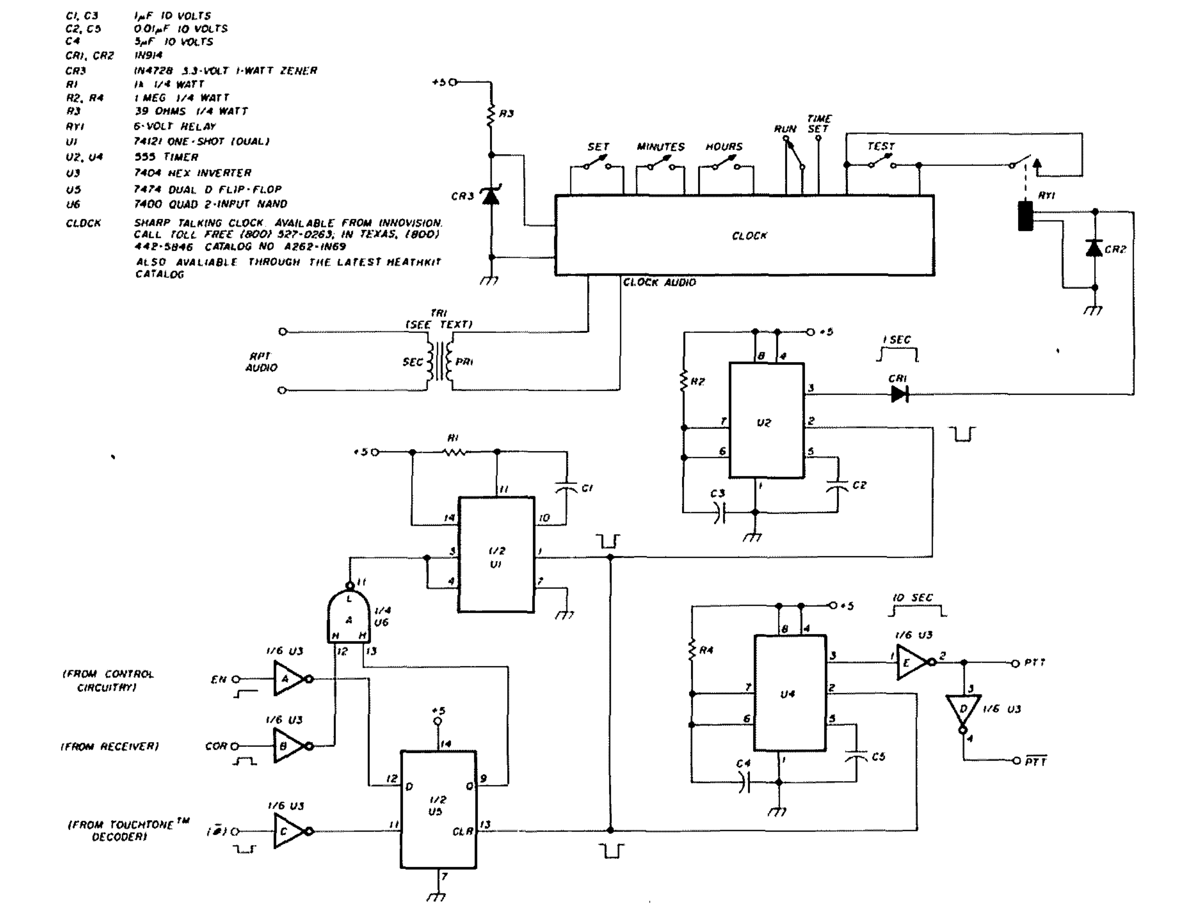
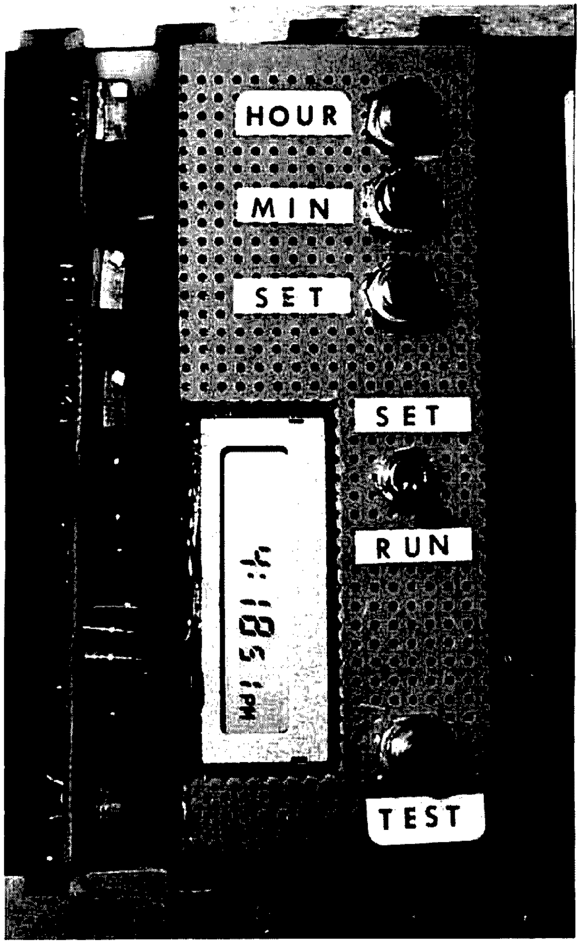


fig. 1. Schematic diagram of the synthesized time identifier.



Closeup of the clock mounted in the control-circuit card cage.

When a pound (#) signal is detected, pin 12 of U6 will be held low by the COR, and pin 11 of U5 will go high, latching pin 9 of U5 high. The high at pin 9 is applied to pin 13 of U6. When a unit starts transmitting, pin 12 of U6 will be held low by the COR, and pin 11 of U5 will go high, latching pin 9 of U5 high. The high at pin 9 is applied to pin 13 of U6. When a unit stops transmitting, pin 12 of U6 will return high and pin 11 of U6 will go low. When pin 11 of U6 goes low, U1 will produce a negative-going pulse on pin 1.

The negative pulse from pin 1 of U1 performs three functions. First, it resets the pound (#) storage flip-flop U5 through pin 13. Second, it triggers timer U2 through pin 2. Third, it triggers timer U4 through pin 2.

IC U4 is a 555 timer with a positive-going output pulse of approximately 5 seconds duration. This output pulse is selected by R4 and C4. The output pulse appears on pin 3 of U4 and is used to hold the transmitter on during the voice time announcement. Inverters D and E of U3 generate PTT and $\overline{PTT}$ for versatility.

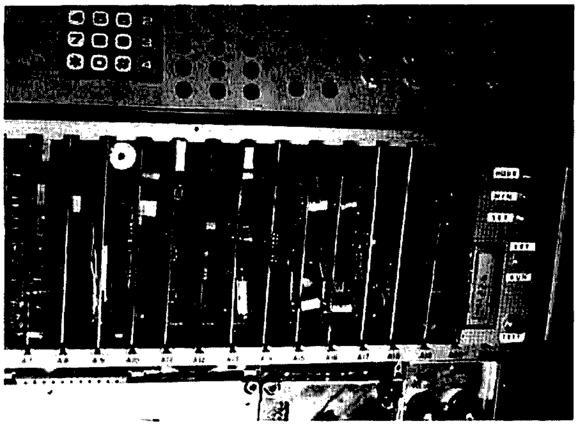
IC U2 is also a 555 timer with a positive-going output pulse of 1 second duration. The output pulse is determined by R2 and C3. The output pulse on pin 3 of U2 drives relay RY1 directly. The normally open contacts of relay RY1 are connected in parallel with the clock activation button, which starts the time announcement routine inside the clock.

Components R3 and CR3 form a 3.3-volt zener-diode regulator to eliminate the need to use the clock's internal batteries. The run-set, hour, minute, and set functions are internal to the clock and may be left alone. However, it may be convenient to run these out to a set of front-panel switches so that the time may be set while the card is still plugged into the card cage. If the clock is not mounted in a manner that prevents access to the set switches, then external mounting of the switches is unnecessary.

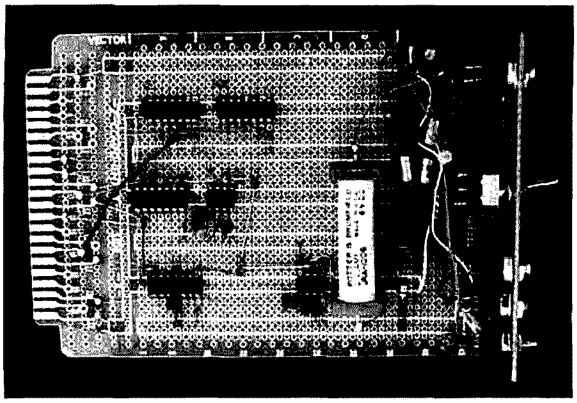
The clock audio is accessed by removing the internal speaker and substituting a matching transformer with a primary impedance of 8 ohms and a secondary impedance that matches the audio circuit that the clock is to drive. In addition to providing impedance matching, the transformer's inductance smoothes out the square-wave output produced by the clock. We found that the transformer filtering was sufficient to provide easily understood speech on the repeater. Since the clock's audio output circuit contains no dc isolation, any attempt to interface the audio without a transformer will kill all audio output.

construction

The control circuitry of our repeater is composed of 44-pin, double edge connect cards. For this reason the entire clock circuit was built on a 4-1/2 × 6-1/2 inch (11 × 17 cm) Vector™ prototype board. A simpler method would be to build the control circuit on a



Repeater control circuits of WB4FQR with the clock to the right.



Details of circuit wiring on the Vector™ board.

smaller board and leave the clock in its original case, bringing out only the speaker audio lines and the activate switch.

The photos show how the clock fits into the card cage and the construction method we used. The clock circuit board was removed from its case and secured to the front of the Vector™ board with a small amount of five-minute epoxy cement. A piece of perf board with a window cutout for the clock display was then cemented to the front of the Vector™ board. The hour, minute, set, time, run-set, and test switches were mounted on this board. The test button is merely another switch in parallel with the clock activate switch.

Number 30 (0.25 mm) wire-wrap wire can be used to connect the front panel switches to the clock and also for some of the longer jumpers on the circuit board. Wiring is in no way critical, nor is parts placement.

adjustments

Once the clock is constructed and interfaced with the repeater, the only adjustment required is the audio level. The volume control is provided on the original clock and can be seen in the photo in the upper right-hand corner of the clock board behind the test switch. If you do not have a method of measuring deviation, simply increase the audio until it is the same loudness as an average mobile signal. Be careful that you do not start distorting the audio.

The clock circuit is very easy to build and can be completed in one day. If desired, any signal may be used to activate the clock. This clock has been in service on WB4FQR/R for nine months with no problems. We have received many favorable comments on it, and it is surprising how well the club has adjusted to having it. The talking clock is an easy, inexpensive, but very useful addition to any repeater.

ham radio

ham radio TECHNIQUES

Bill Orr W6SAI

In a recent column I discussed the problems of cleaning up radar-oven RFI so it didn't wipe out the nearby TV receiver, the kitchen radio and my station receiver. Once that was behind me, I thought I was in the clear, with happy days ahead. This was not to be.

A few days ago my neighbor came by and asked if I knew why his radio-controlled garage door opened and closed at odd times of the day and night. He had called the installer, who came out, charged a service call, and left without doing anything.

I had a hunch I knew what the problem was, so I went to look at the installation. It was a brand-new digital control job with a sub-audible security system so no one but the owner (ha!) could open the garage door. It operated in the 390 MHz range.

Before I did anything, I called a ham friend in the business of installing radio-controlled garage doors. I asked him about the mysterious operation of the garage door. Did he know anything about that kind of problem, and could my ham transmitter be the culprit?

It turns out he knows a lot about the problem. He explained that about a year ago, the majority of companies manufacturing garage-door remote control devices changed from a metal box containing the receiving and coding equipment to a plastic box to save a few pennies.

Since then, he's developed a lucrative business desensitizing garage-door receivers to spurious rf signals. "Even a military plane flying overhead using radio gear in the 400 MHz range can open a dozen garage doors," he confided happily. "Police cars, delivery trucks, CBers and hams, too, can open the new generation of garage doors, because the protective rf shield around the sensitive devices is missing."

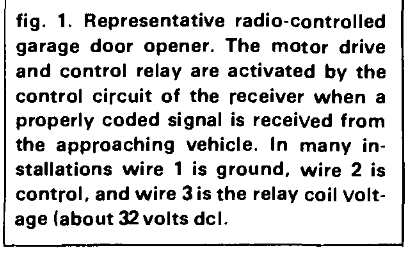


fig. 1. Representative radio-controlled garage door opener. The motor drive and control relay are activated by the control circuit of the receiver when a properly coded signal is received from the approaching vehicle. In many installations wire 1 is ground, wire 2 is control, and wire 3 is the relay coil voltage (about 32 volts dc).

Well, I didn't want to spoil a good thing for him, but I wanted to know if he had any suggestions that would ease my problem.

"Simple," he replied. "There are two cures. The first, and easiest, is to prevent rf from entering the receiver the wrong way. Most installations have a remote push-button located near the door of the garage that leads into the house. The leads from the push-button to the receiver are usually quite long and act as a very good pick-up antenna for hf and VHF signals. (The leads in my neighbor's case were about 25-feet (7.62 m) long.) Place a filter in the leads and in most cases, the receiver will desensitize to locally generated rf (**fig. 1**)."

"And what if that doesn't work?" I asked.

"If that isn't enough, you have to place the whole receiver in a metal box, bypass the leads coming out of the box and — as a last resort — place a high-pass filter in series with the pick-up antenna."

"I hope I don't have to go through that," I gulped.

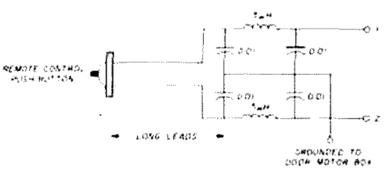


fig. 2. A simple filter made on a piece of printed circuit board cleaned up the interference problem. Filter was mounted directly at the metal motor control box. Since, at the time, I didn't know if either wire 1 or 2 was ground, I filtered each and brought the filter ground to a sheet metal screw on the motor box. The inductors were small, 1/4-inch diameter surplus inductors wound on a 1-inch long form.

The next day I made a simple rf filter on a piece of printed circuit board (fig. 2) and I made a long control lead of zip-cord so I could place my transmitter on the air when I was standing outside my neighbor's garage.

My neighbor, a friendly chap, was mystified by all the activity, and he was astonished when I keyed my transmitter by means of the long control cable and his garage door mysteriously opened while we were both standing there!

The next step was to scramble up a short ladder, disconnect the wires from the receiver box to the remote control push-button and insert the filter in the leads. I did this and then once more keyed my transmitter. Nothing. The door stayed shut! Problem solved.

The evening I reported my success to my helpful friend and thanked him for his wisdom. He told me I should have been in San Francisco the time a certain new television station went on the air. As soon as they threw the switch at the transmitter, hundreds of garage doors opened in the city, as well as the doors on fire houses and some police stations! It nearly caused a panic.

"In fact," he confided, "That's what set me up in business!"

After all the brouhaha died down, I called the manufacturer of the garage door controller device and spoke to a bright young lady who was a "trouble shooter." Without tipping my hand, I explained the problem. Oh, yes, she had heard of it. The cure was to bypass the leads running from the receiver to the remote push-button. "Just place a 0.01 μF capacitor from terminal 2 (the control wire) to terminal 1 (ground). That will clean up the trouble."

I then had the temerity to ask her why, if they knew that all this mess could be cleaned up by adding a cheap bypass capacitor, why, why wasn't it installed at the factory?"

She allowed as that might be a good idea, and closed the conversation by telling me that she would "suggest it to the Engineering Department."

so there you are

For want of a cheap capacitor, a whole new generation of garage door radio-control devices seems to be wide open to control by a nearby, strong radio signal. What short-sightedness!

In a nutshell, then, if you have garage door RFI you might consider these three steps:

1. Bypass the remote push-button leads at the receiver with a 0.01 ceramic disk capacitor.

2. If that doesn't do the job, place a filter in the push-button leads.

3. As a last resort, completely shield the receiving unit, bypass all leads and place a high-pass filter in the antenna lead.

Now, save me from any more wide-open, RFI-prone electronic consumer items built by those who should know better for those whose only concern is price!

An afterthought: the garage door receiver and associated circuitry is also capable of creating TVI in the presence of a strong local signal. I think all those unshielded and unfiltered ICs in it are the culprits. In any event, there's a short item in the Jan-

uary, 1982, issue of *QST* magazine (pages 49-50) by John Hartung, W7THY, who chased channel 2 and 6 TVI caused by his transmitter for years. He finally traced it to a Sears garage door opener that was distorting the transmitting signal and reradiating it in the television channels. He ran shielded wire to the remote push-button and incorporated a simple filter in the line. This cured the TVI.

the W1PLH compact 10-meter antenna

The ten-meter band should be coming back to life now that the summer season is over. Interest always runs high on simple, compact antennas for that band. Here's an interesting antenna submittd by Charlie, W1PLH (**fig. 3**). The antenna measures less than four feet (1.2 meters) on a side and can be built around a simple wood or bamboo framework. It looks something like a horizontal Quad loop, but it is merely a loaded dipole made up of 300-ohm TV ribbon line. The wires of the line are connected in parallel, so no impedance transformation takes place.

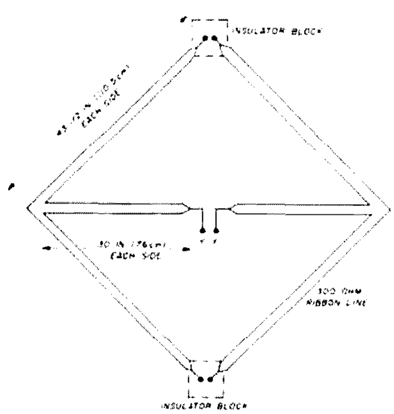


fig. 3. Top view of the W1PLH horizontal antenna for 10 meters. Device is made up of ribbon line, with wires connected in parallel to make a fat element. Antenna is fed at points F-F with a 1-to-1 balun and coaxial line. A lightweight wood frame supports the antenna. Directivity is bidirectional, through the insulator blocks.

Top and bottom physical terminations of the lines are two small insulators; the whole assembly is mounted parallel to the ground. W1PLH placed his antenna atop a 17-foot (5.2 m) high wooden mast. With the dimensions shown, the antenna is resonant near 28.8 MHz, but exhibits a very low SWR (less than 2-to-1) over the range of 28.55 to 28.95 MHz.

Because of its small size, the antenna is very unobtrusive and is recommended to those Amateurs wishing to retain a low profile with their neighbors, yet enjoy contacts on the air with their friends.

the N6CX 40-meter mobile home antenna

The editor of the PARG Bulletin (Pacific Amateur Radio Guild) — Hal Glen, N6CX — has an interesting solution to the invisible antenna for mobile home use. His idea is shown in **fig. 4**. This data was forwarded to me by Bob, W6CYL, who vouches for the efficiency of the antenna. He calls it "the sneaky antenna for mobile home hams, or, it is better to be sneaky than off the air!"

Basically, the antenna looks like a sixteen-foot (4.9 m) flag pole, complete with flag. The main assembly is 1¼-inch plastic pipe, and the flag pole is made in two sections. The top section has a metal toilet tank ball (**A**) connected electrically to the top end of a helical winding (**B**) inside the flag pole (**C**). The ball is mounted by a ¼-inch bolt to an end cap secured to the pole.

The antenna itself is a ¾-inch pipe about 10 feet (3.0 m) long, telescoped within the larger pipe. The smaller pipe is wound with 68 feet of No. 16 enameled wire, spaced as evenly as possible over the complete length.

The bottom end of the winding passes through a tee fitting and a ¾-inch diameter nipple, which is bolted to the wall of the mobile home with a matching flange. The nipple should

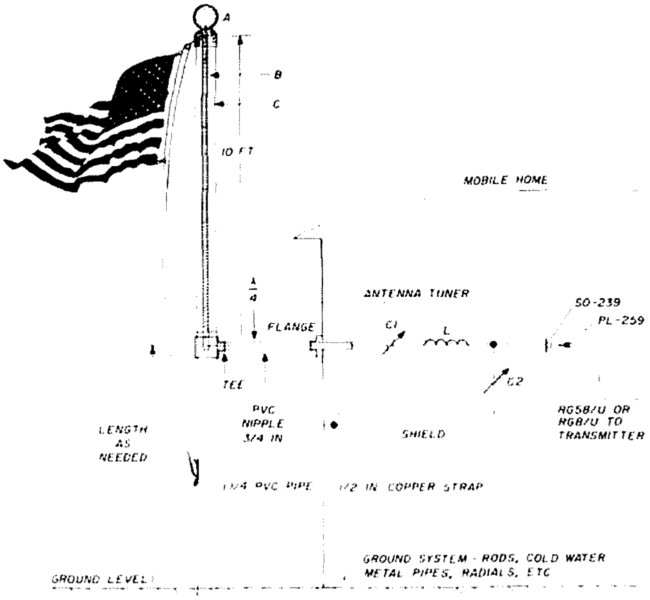


fig. 4. The N6CX 40-meter vertical antenna designed for a mobile home. There's no reason why the design couldn't be modified for other bands.

be long enough so the antenna clears the eaves of the mobile home. In addition to serving as a lead-in, the nipple also braces the antenna against the wind.

The lower section of the antenna, which acts merely as a support, is a section of 1¼-inch PVC, the length adjusted to fit the particular installation. The bottom of the PVC pipe is fitted into a hole dug a foot or two into the ground.

A pulley is installed at the top of the antenna for a halyard and flag. The halyard should be nylon rope, or equivalent.

The helical-wound vertical antenna has a feed-point impedance of about 5 ohms at resonance (determined by the number of turns on the winding). A ten-to-1 toroid transformer will do a good job of matching the antenna to a 50-ohm line. Or, the tuning unit shown will do the job. Capacitor C1 is 1500 pF and C2 is about 1350 pF. The units used were flea market jobs from old trf broadcast receivers. The coil, L, is about 0.7 μH (eight turns, spaced to one inch long, ¾-inch diameter of #12 wire).

A good ground system is absolutely essential with this antenna. The ground connection is a short length of ½-inch wide copper strap. The tuning unit should be placed near the operating table and the ground lead run from this point to the actual ground. N6CX uses a combination of ground rods, cold water pipe, and radials for his ground, and it seems to do a good job.

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HAM CALENDAR November

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
W1AW Schedule April 25-October 24, 1982 MTWThFSSn - Days of Week Dy - Daily W1AW code practice and bulletin transmissions are sent on the following schedule: EDT Slow Code Practice MWF: 9 A.M., 7 P.M.; TThSSn: 4 P.M., 10 P.M. Fast Code Practice MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M. CW Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. RTTY Bulletins Dy: 6 P.M., 9 P.M., 12 P.M.; MTWThF: 11 A.M. Voice Bulletins Dy: 9:30 P.M., 12:30 A.M. CDT Slow Code Practice MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M. Fast Code Practice MWF: 3 P.M., 9 P.M.; TTh: 8 A.M.; TThSSn: 6 P.M. CW Bulletins Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M. RTTY Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. Voice Bulletins Dy: 8:30 P.M., 11:30 P.M. PDT Slow Code Practice MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M. Fast Code Practice MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M. CW Bulletins Dy: 2 P.M., 5 P.M., 8 P.M.; MTWThF: 7 A.M. RTTY Bulletins Dy: 3 P.M., 6 P.M., 9 P.M.; MTWThF: 8 A.M. Voice Bulletins Dy: 6:30 P.M., 9:30 P.M.	**WEST COAST BULLETIN** 9 PM PDT (8 PM PST 0400 UTC) 3540 kH, A-1, 22 WPM - 1 **1**	**2**	**YLRL ANNIV. PHONE CONTEST** - 3-4 **3**	**ENCON & SOLAREX CORP. FREE SEMINAR** Photovoltaic seminar (electricity from the sun) will be held at Dearborn Hyatt Regency, Dearborn, MI. For more info contact Encon Corp., 2758 Schoolcraft Rd., Livonia, MI 48150, (313) 261-4130 - 4 **4**	**HAMPDEN COUNTY RADIO ASSOCIATION'S ANNUAL AUCTION** Granger School, intersection of Rtes. 57 & 187, Feeding Hills, MA. For more info contact N8BOU - 5 **5**	**FOOTHILLS ARC ANNUAL SWAP & SHOP** - Bruno Church, South Greensburg, PA. Contact W3TTN - 6 **6**
CABARRUS ARS ANNUAL HAMFEST - Concord Boy's Club, Spring St., Concord, NC. For more info contact C.A.R.S., P.O. Box 1290, Concord, NC 28025 - 7 **R.F. HILL ARC's 6TH ANNUAL HAMFEST** - Sellersville National Guard Armory, Sellersville, PA. For more info contact R.F. Hill ARC, Box 29, Colmar, PA 18915 - 7 **CZECHOSLOVAKIAN CONTEST** - 7 **7**	**8**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **9**	**10**	**11**	**12**	**50TH ANNIVERSARY OF THE SANDUSKY (OH) RADIO EXPERIMENTAL LEAGUE QSO PARTY** - 13-14* **EUROPEAN RTTY CONTEST** - 13-14 **13**
10TH ANNUAL FORT WAYNE HAMFEST - Held by the Allen County Amateur Radio Technical Society at Allen County Memorial Coliseum. For more info, contact KA9GWE - 14 **14**	**WEST COAST BULLETIN** - 9 PM PDT (8 PM PST 0400 UTC) 3540 kH, A-1, 22 WPM - 15 **15**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **16**	**17**	**18**	**19**	**HONEYWELL 1200 RADIO CLUB & WALTHAM ARA** - Annual Amateur Radio & Electronics auction at the Honeywell Plant, 300 Concord Road, Billerica, MA. Contact N1BUB - 20 **ARRL PHONE SWEEPSTAKES** - 20-21 **20**
21	**22**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **23**	**24**	**25**	**26**	**27**
28	**29**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **30**				
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operation upgrade: part 11

The eleventh part in a continuing series designed to help you upgrade your ticket

Previous articles in this series have explained the fundamentals of electricity, passive and active devices, power supplies, CW transmitters and receivers, and a little about radio wave propagation and different antennas. In this article we will explain how amplitude modulation is produced and detected.

Amplitude modulation (a-m or A3) was *the* method of communicating by voice over radio prior to the early 1950s, before single-sideband (SSB or A3J) made its entrance on the Amateur bands. Since SSB is based on double-sideband a-m you should understand the basics of this older form of voice communication before we investigate how SSB systems work. Even today a-m stations are heard on 160, 80, 10, and some VHF bands. Standard broadcast band and high-frequency international broadcast stations use A3, and television stations use amplitude modulated video (A5). A-m is a relatively easy and inexpensive way for the experimenting Amateur to get on the air with voice communications. It is legal to use on any Amateur band in the phone sections.

an amplitude transmitter

The simplest a-m transmitter is an oscillator with a carbon microphone connected in series with the antenna. Such a system is called absorption modulation, because a carbon microphone absorbs more and less power when its diaphragm is vibrated in and out by sound waves, leaving less and more power to

By *Robert L. Shrader, W6BNB*, 11911 Barnett Valley Road, Sebastopol, California 95472

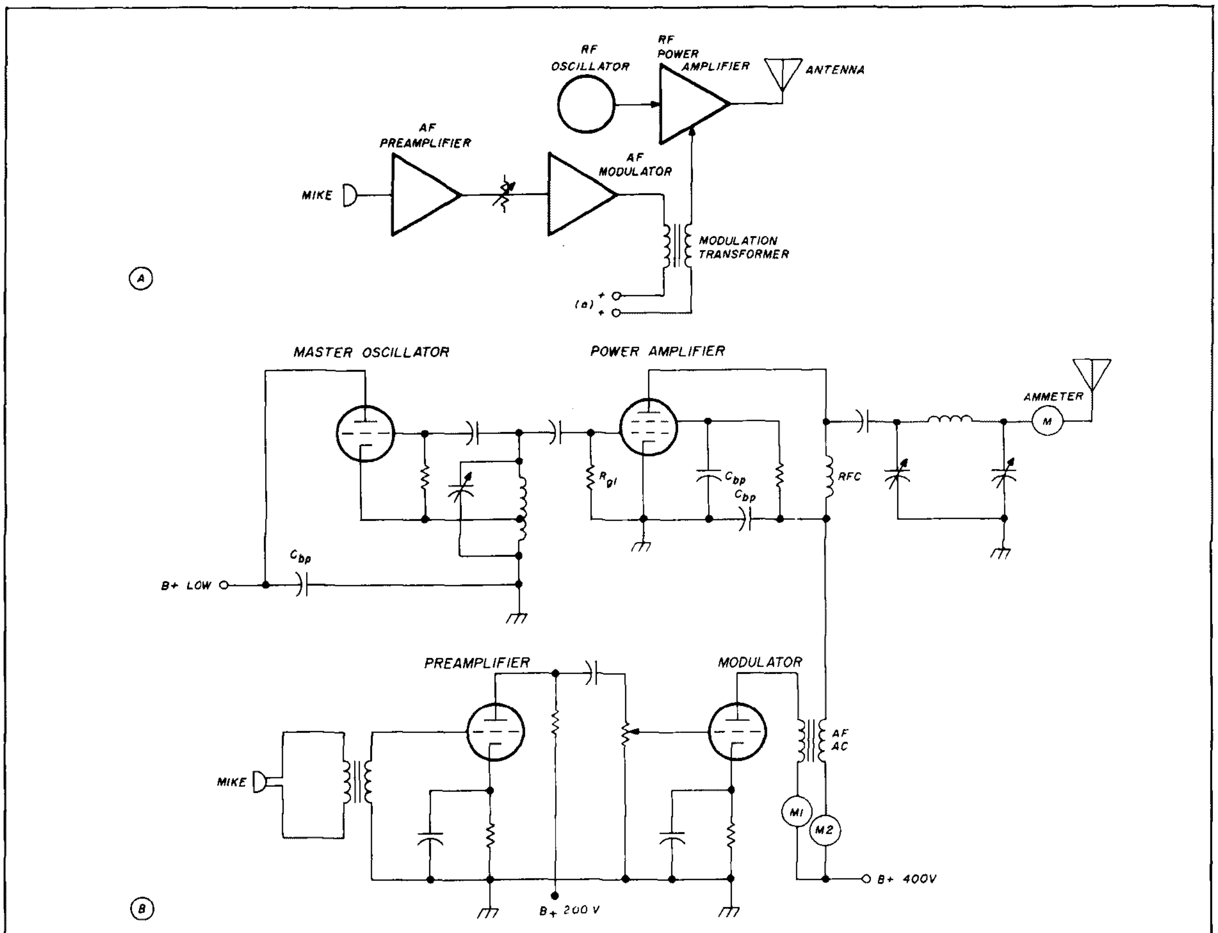


fig. 1. Basic plate modulation system, (A) block diagram, (B) schematic.

be radiated by the antenna respectively. The resulting output rf wave varies in amplitude (strength) in step with the voice waves' modulation of the microphone's resistance. This produces very little rf amplitude change, modulates only very low rf power levels, and produces a simultaneous change in, or modulation of, the oscillator's frequency — which is undesirable.

A reasonably successful amplitude-modulated system can use a master oscillator power amplifier (MOPA) CW type transmitter (part 7, June, 1982) with a microphone feeding audio-frequency amplifier stages that vary the plate supply voltage to the PA stage. **Fig. 1** presents this system in block and schematic diagram forms. The stages are shown using vacuum tubes since most a-m rigs used them. Today, JFETs, VMOSs, or BJTs might be used instead. The block diagram shows an rf oscillator driving a class C (must be grid-leak biased) rf power amplifier coupled to an antenna. The low af voltages produced by the microphone are amplified, first by the preamplifier (*pre* because it is ahead of the gain control), and finally by the modulator stage. The job of the modulation system is to produce voice af ac voltages across the secondary of the modulation transformer with peaks equal to the plate voltage of the PA stage, which would be 400 volts in our case. The result is the production of maximum amplitude changes of the rf carrier power without causing distortion. The af ac peak voltages should equal +400 and −400 on the two half-cycles of the af ac. This produces voltages between the plate and cathode of the PA tube that vary from 400 volts with no modulating af ac added, to +800 volts at the positive peak, and down to zero volts at the negative peak of the modulating voltage.

Two conditions must be considered when discussing a-m systems. One is when undistorted sine-wave

af ac is fed into the preamplifier, and the other is when voice ac produces the modulation. When the modulating voltage is sinusoidal, the required af modulating power is exactly half of whatever the plate power input to the PA stage happens to be for 100 percent modulation. For example, if the PA I_p meter M_2 reads 100 mA (0.1 A), the power input to the PA is $P = EI$, *or 400 (0.1)*, or *40 watts*. If the PA is 60 percent efficient, the output power radiated by the antenna will be *40 (0.6)*, or *24 watts*.

Since a single device audio amplifier must be biased to class A to produce undistorted sinusoidal audio output, and since class A stages are usually only about 33 percent efficient, at least 60 watts must be fed to the modulator tube plate circuit to produce the required 20 watts (33 percent of 60 watts) of af ac for 100 percent modulation. Therefore, M_1 would read (from $P = EI$, and rearranging the formula to solve for current) $I = P/E$, *or 60/400, or 0.15 A, or 150 mA*. Thus, the power supply must produce 400 volts at *100 + 150 mA*, or a total of *250 mA*.

However, with most voices, only about half of the sine-wave af power requirement will produce voice peaks high enough to produce full or 100 percent modulation. Therefore, the modulator dc current would only be about 75 mA at full operation, and the power supply would only have to supply *75 + 100, or 175 mA*. How about overall efficiency? To transmit a fully voice-modulated 24 watt rf carrier it requires from the power supply at least $P = EI$, *or 400 × 0.175*, or *70 watts* of dc power. The efficiency is therefore *(24/70)100*, or 24 percent. This is not very good when we compare it with the 60-70 percent efficiency of modern SSB transmitters which balance out all the carrier power, and then filter out one of the two developed sidebands. Sidebands? What are they?

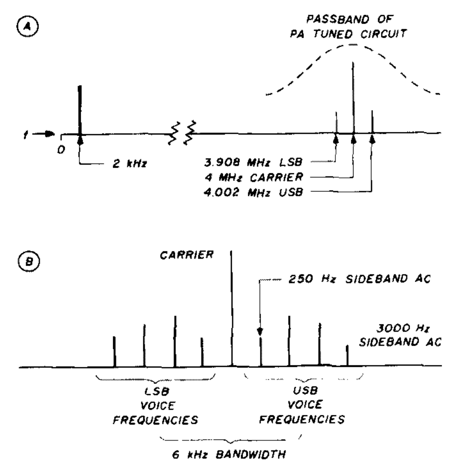


fig. 2. (A) Spectrum of carrier, sidebands, and rf passband of PA tuned circuit. (B) carrier plus Voice sidebands and bandwidth.

sidebands

Amplitude modulation is actually a form of heterodyning or mixing two frequencies (rf carrier and voice af) in some nonlinear circuit (the plate circuit of a PA stage). If an rf carrier is modulated by an af tone there will be four frequencies as the output: the rf; the af; the sum of the two; and the difference between the two.

Let's consider the carrier to be 4 MHz, or 4,000,000 Hz, and the modulating ac to be 2 kHz, or 2,000 Hz. The sum frequency will be 4,002,000, and the difference frequency will be 3,998,000 Hz (**fig. 2A**). The tuned PA circuit is rather broad tuning (dashed curve) and will accept the carrier plus the sum and difference frequencies and transmit all three. But the af is too low a frequency to produce any voltage-drop across the 4-MHz tuned circuit and does not appear anywhere in the output.

The sum frequency is higher than the carrier frequency, so it is called the upper sideband (USB). The difference frequency is the lower sideband (LSB). In the case of voice modulation, only the frequencies between about 250 Hz and 3000 Hz are required to convey intelligence. Therefore, the width of either the upper or the lower sidebands will be about 2750 Hz, as indicated in **fig. 2B**. Note that each voice tone produces equal-amplitude upper and lower sideband signals. This is a double-sideband with carrier signal, called a-m. If the carrier is reduced to zero or nearly zero, the signal produced is known as A3H. If the carrier is cancelled and one set of sidebands is filtered out and not transmitted, the emission is known as single-sideband, SSB or A3J. Note that our 4-MHz a-m signal would be illegal because the USB is out of the band!

The bandwidth of an amplitude modulated transmission is the spread of frequencies between the highest USB ac signal to the lowest LSB ac signal. Amateur a-m voice transmissions must not exceed 6 kHz in bandwidth (3 kHz as the top audio tone transmitted). Little energy is usually transmitted at frequencies lower than 250 Hz for voice transmissions. What should be the bandwidth of an SSB voice emission? How about 2750 Hz, or 2.75 kHz?

Standard a-m broadcast transmitters (535-1605 kHz) and high-frequency international a-m broadcast stations modulate with audio frequencies up to at least 5 kHz, and many up to 10 kHz or higher, with the lowest frequencies down to 50 Hz. The wider the bandwidth of the sidebands, the more faithful the reproduction of voice and musical sounds (any music transmission is illegal for hams).

the modulated envelope

There is another way to consider amplitude modulation signals and their carriers. If a sample of the rf ac carrier is coupled to the vertical input of an oscilloscope, with the horizontal sweep a 20 to 30 Hz sawtooth ac, an illuminated band will stand still across the screen, as illustrated in **fig. 3A**. We can say the scope is showing an envelope carrier pattern. With no modulation the carrier alone is known as an AØ emission. If the carrier is increased in power the envelope band will extend higher and lower. If the carrier is reduced to nearly zero there will be only a thin line across the center of the screen. In **fig. 3B** we see two cycles of sinusoidal modulation have been applied to the carrier. The first cycle increases by only 50 percent at its peak, whereas the second cycle produces 100 percent modulation (100 percent peaks are twice the carrier level, and the minimums go to zero output for an instant).

If the modulator stage feeds more than the necessary amount of voltage in series with the PA plate circuit, a condition such as that illustrated in **fig. 3C** will occur. Here the positive peak of modulated wave is greater than twice the carrier level, which is not likely to cause any troubles. But on the negative peak of modulation, the negative modulating voltage drives the plate voltage below zero to some negative value. As a result, for a period of time nothing is transmitted. This results in a very rapid drop-off of the modulated waveform and also a very rapid increase from zero toward the carrier level. The abrupt change from something to zero and then zero to something represents the wave shape of a very high frequency ac. Very high frequency ac will produce sidebands far removed from the carrier. They produce interfering sidebands far from the carrier on both sides. Such widely displaced noise-type sidebands are called splatter, buckshot, and other derogatory terms by Amateurs trying to listen on frequencies near a carrier with this kind of over-modulation.

Over 100 percent modulation is not the only thing that can cause splatter. If the af amplifiers produce distortion of the modulating signal, harmonics (multiples) of these modulating frequencies will appear in the modulated output. These harmonics develop high frequency USBs and LSBs far removed from the carrier *frequency*.

Note that the oscilloscope pattern is not showing the sidebands of a modulated signal. It *is* showing the results of sidebands, though. If the sidebands were not generated by modulation the amplitude waves of the carrier would not increase and decrease.

A scope provides an excellent method of tuning transmitters. All rf stages are tuned for a maximum height of the illuminated band shown on the screen.

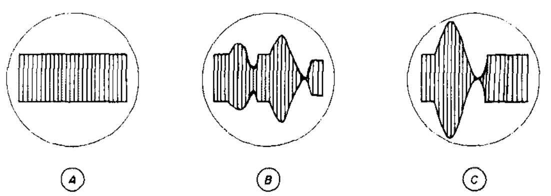


fig. 3. Oscilloscope presentations. (A) Carrier alone, (B) carrier with a 50 percent and a 100 percent modulated wave, (C) carrier with an over-modulated wave.

For modulation checks the microphone can be spoken into and the af gain control increased until the negative peaks of modulation drop to zero, or the waveform begins to show changes of wave shape, or flattening of the peaks. Such distortions are reduced by reducing the gain control.

other methods of modulating

We have explained plate modulation (it would be collector or drain modulation if BJTs or FETs were used) in which the modulating voltages are added to the plate voltage. The more total E_p the greater the rf power output. The less the E_p the less the rf power output. If you watch the antenna ammeter shown in **fig. 1B**, the carrier alone might develop 1 ampere. When 100 percent sinusoidal modulation is applied, the ammeter should increase by 6 percent, to 1.06 amperes. With voice modulation peaking at 100 percent the ammeter will hardly move at all. This is because the average power of speech ac is very low, even if the peaks are high. The average of a sinusoidal wave is always 0.636 of the peak. The average of voice wave voltages is rarely over 0.2 or so of the peaks (unless voice-peak clipping is used in the af amplifiers). For this reason an antenna ammeter is almost worthless as an indicator of modulation percentage. It can be handy to indicate whether the transmitter and the final amplifier are tuned to resonance properly, however. At resonance the antenna ammeter will peak and the PA I_p will dip to a minimum reading. Today there are few antenna ammeters in use. Instead, Amateurs use remote field-strength meters, or a form of rf ac antenna voltmeter to tell when maximum radiated power is being developed.

The modulator shown in **fig. 1B** is a single tube class A audio amplifier. When a class A stage is working properly there will be no change in its plate current, meter M_1 in our circuit, whether there is a very low signal or a very high signal value being amplified. If the meter does move, it indicates distortion of some kind, usually af input overdriving the stage. In most cases, modulator stages use push-pull class AB or class B amplifiers, which have efficiencies of

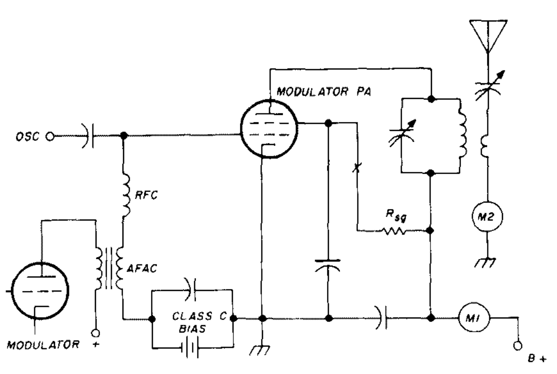


fig. 4. Grid modulated tetrode, screen-grid modulated if the af ac is added at point X.

perhaps 50 percent, rather than the approximately 33 percent of class A stages.

If the modulating voltage is applied in series with the grid circuit (base or gate for BJTs and FETs) and the bias voltage, the output of the stage can also be modulated. Consider **fig. 4**, in which the af ac is added in series with the bias voltage. The stage is biased to class C, which means that with no rf ac drive from the oscillator the bias is high enough to cut off the I_p completely. With a little oscillator rf ac drive there will be a little I_p flowing and the plate tank circuit can be tuned to a minimum I_p value, as indicated by M_1. An antenna ammeter would peak at the same tuning point. As the drive from the oscillator increases the I_p and antenna current values increase up to a point. Increasing the drive further will produce no greater antenna current. The drive should be decreased to a value a little below maximum antenna current. Now, when af ac is added to the bias voltage, the plate current will increase with positive peaks of af ac and decrease with negative peaks. The envelope waveform seen on an oscilloscope with grid modulation should look the same as with plate modulation, except that it is a little more difficult to determine the correct values of drive and antenna coupling to produce undistorted modulated output. Grid modulation is also known as grid bias modulation or efficiency modulation, because under modulation the efficiency of the modulated stage rises from a low value up to about 60 percent to produce the high positive peaks of modulation without adding more plate voltage to the stage. If the PA were a triode it would have to be neutralized, but its operation would be essentially the same as with the tetrode shown.

If the modulation transformer is removed from the grid circuit and connected instead in series with the screen grid circuit at the place marked X, screen grid modulation would result. Whereas grid modulation requires almost no af ac modulating power, screen grid modulation requires about 10 percent as much as plate modulation.

The circuit in **fig. 5** shows a pi-network output bipolar junction transistor rf PA being modulated by a pair of BJTs in push-pull. If 100 percent modulation cannot be produced with the circuit as shown, some of the modulating ac voltage can be fed to the driver stage (dashed circuit with resistor, and disconnect $+V_{CC}$). Neutralization may be necessary (dashed circuit with capacitor C_n). This modulation is somewhat similar to using plate and grid modulation at the same time, which in vacuum tube circuits is known as cathode modulation because the cathode has both plate and grid-modulated currents flowing through it. (The modulating voltage can also be connected directly in series with the cathode lead.)

undesirable results

In all modulation systems it is important that distortion be held to a minimum. This means the microphone must produce clean signals, the audio amplifiers and modulator must not be overdriven enough to produce distortion and unwanted harmonics. The impedances of the modulation transformer must match both the modulator stage and the impedance of the stage being modulated. The antenna must be coupled just tight enough to reflect back on the modulated rf PA the proper impedance to produce undistorted modulation. While there may be considerable latitude in plate-type modulations, grid-type modula-

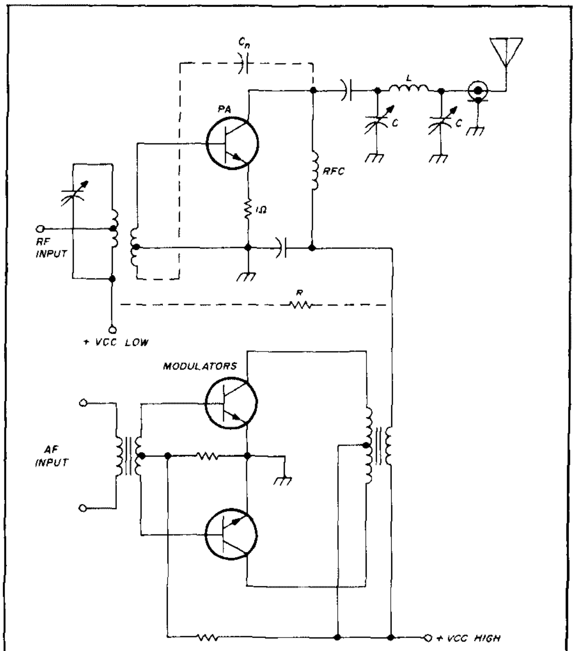


fig. 5. Collector-modulated BJT by push-pull BJTs.

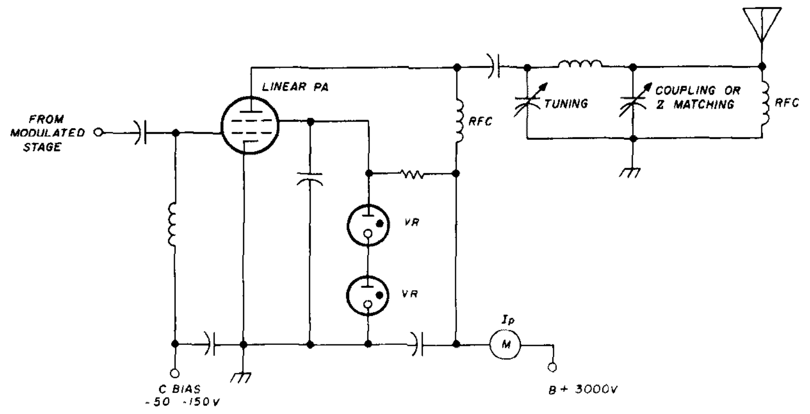


fig. 6. Linear amplifier following a low-level modulated stage.

tion systems are much more difficult to adjust for optimum or near optimum modulated output.

If the dc of the power supplies is not adequately filtered, or if the filter capacitors dry out, the power supply voltage ripple will produce an rf amplitude variation that appears in receivers as a low frequency (60 or 120 Hz) hum modulation riding along with the voice modulation. New filter capacitors are required or more filtering should be added.

About the only way to be sure a transmitter is not over-modulated and producing splatter is to monitor the output signal with an oscilloscope. The negative peaks of modulation should not be allowed to hit zero; one way to prevent this is to use clipper circuits in the preamplifier. Such a circuit clips off all voice peaks exceeding a set limit. Since clipping produces distortion and harmonics, clippers must be followed by a 3-kHz lowpass filter to prevent the harmonics from modulating the PA and producing sidebands far removed from the carrier frequency.

linear amplifiers for a-m

To produce the maximum 1 kW of input power allowed to Amateurs, an a-m PA stage would require about 250 to 500 watts of undistorted audio power to do the modulating. This requires large, heavy af equipment. It may be easier to modulate a lower level rf stage and amplify the modulated rf signal with a linear amplifier. For example, if the linear amplifier is a beam-power tetrode it may require only 20 watts or less of modulated rf signal to drive it to its full output capability with 1 kW of input dc plate power. Under this condition the modulated rf amplifier could be a 40 watt dc-input stage, requiring only 10 to 20 watts of audio to modulate it. This level of audio is relatively simple to develop.

Linear power amplifiers are often beam-power tetrodes rather than triodes because they require much less driving signal (have more gain) and do not need to be neutralized. (Grounded-grid triode stages do not need to be neutralized but require high drive.) The circuit shown in **fig. 6** represents a linear amplifier that might be used with a low-level amlitude-modulated transmitter. Since the amplifier must amplify what is fed into it without distorting it in any way, a linear amplifier will have to be biased to class A, AB, or B. It requires a well-regulated bias supply, a well-regulated screen grid supply (by using voltage regulator tubes in this case), and a well-regulated high voltage plate supply. Remember, only class A could be used with a single tube in audio amplifiers. When class AB or B is used, the bias voltage is higher so that on the negative half-cycle of the input the active device would go into cut-off and part of the input signal would be missing in the output.

In rf linear amplifiers, however, the output signal is the result of the flywheel oscillation of the output LC circuit. The LC circuit oscillations make up for the part of the negative input cycle that might be missing. As a result, an rf linear amplifier may use a single-ended circuit (one active device). In most cases the linear uses class AB for slightly higher efficiency than is possible with class A. Even so, when amplifying a carrier plus modulation the efficiency of the amplifier will run only around 35 percent efficient. (When used to amplify SSB with no carrier being transmitted it can operate at an efficiency of over 60 percent.)

The rf choke* between antenna and ground is to leak off any static charges the antenna may pick up

*It can also act as a crowbar shorting the plate supply to ground in case of failure of the plate-blocking capacitor — protecting the antenna circuit (and operator) from high voltage. **Editor.**

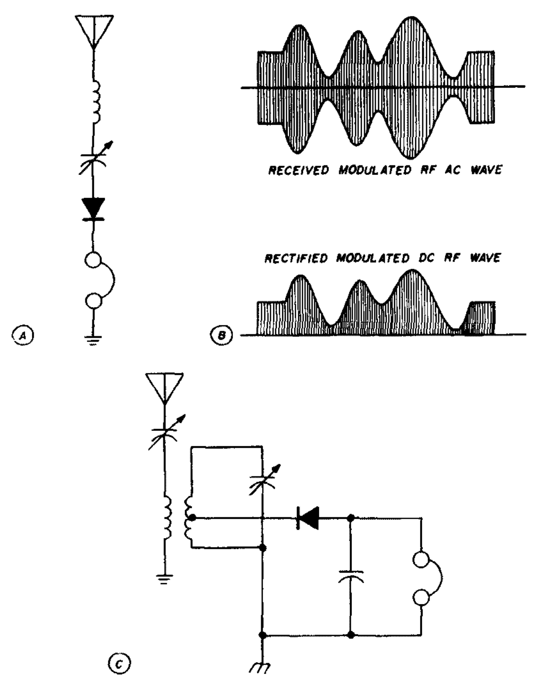


fig. 7. (A) Simplest diode detector, (B) modulated rf and same signal rectified, (C) basic diode (crystal) detector receiver.

when charged clouds pass overhead, which can sometimes amount to thousands of volts.

a-m detectors

Detectors for CW (A1) signals (discussed in July, 1982) require a means of heterodyning the incoming code signals with some kind of a local oscillator to produce a beat tone audible to the operator.

Amplitude modulated signals contain their intelligence not in coded dots and dashes but in the amplitude modulation of the carrier wave with its sidebands. The simplest type of a-m detector is a tunable antenna, a diode, and a pair of earphones, **fig. 7A**. When the antenna wire, inductor, and capacitor are resonated at the frequency of some nearby a-m transmitter, the diode will rectify the rf ac to the varying amplitude pulses of dc, **fig. 7B**. The varying amplitude pulses will attract and release the earphone diaphragms at the modulation frequency rate, producing sound waves that can be heard. Unfortunately, if there are several nearby stations on frequencies relatively close together, the detector will detect them all, because one tuned circuit does not discriminate against other frequencies very well. It is said to have poor selectivity.

A far better detector-receiver is shown in **fig. 7C**. In this circuit there is first a tuned antenna with which to try resonating at only one carrier frequency. Coupled to the tuned antenna circuit coil is a secondary coil which is also tunable. When it is tuned to the same frequency as the antenna circuit, adjacent frequencies will be considerably attenuated. Now only one station should be heard in the earphones. This is the basic idea of the original crystal detector receivers used from about 1910 to the mid-Twenties. Surprisingly enough, it is essentially the same detector circuit used today in modern a-m superheterodyne receivers. The further the diode and earphones (the load) is tapped down the coil the higher the Q of the LC circuit and the better the selectivity of the secondary circuit.

There is another way of looking at a-m detection. Amplitude modulation is the result of beating a carrier ac with audio ac to produce a carrier-plus-sidebands output. When this carrier plus its sidebands are received and fed into a nonlinear circuit (diode detector) the sidebands mix with the carrier and produce sum and difference frequencies. These sum and difference frequencies are the same as the original audio frequencies at the transmitter. The earphones make them audible to the listener.

a-m receivers

Basic CW receivers discussed in the July, 1982, article are the tuned radio frequency (TRF) amplifier receiver and the superheterodyne. An a-m superheterodyne is actually the front-end of one heterodyne TRF receiver coupled to the input of a second complete TRF receiver, but using a diode detector, as indicated in the block diagram (**fig. 8**).

The tunable rf amplifier (with arrow), the tunable first detector or mixer, and the tunable local oscillator are all ganged to tune together (indicated by the dashed lines) across the radio spectrum. They would be the first two stages of a CW TRF, and form the front end of the a-m superheterodyne. The fixed-tuned i-f amplifier (450 kHz usually), the fixed-tuned diode detector (450 kHz), the volume control, the af amplifiers and the loudspeaker form the second TRF system and complete the superheterodyne system. Note that something new has been added. It is the automatic gain control (AGC) circuit which uses some of the dc voltage developed when the diode type second detector rectifies the i-f signal being fed to it. This negative (or reverse bias) AGC voltage is fed back to the i-f and the rf amplifier input circuits. A strong signal into the second detector develops a high AGC reverse bias voltage which reduces the gain of the rf and i-f amplifiers, thereby reducing the voltage to the second detector. Weak signals at the second detector produce almost no reverse bias and the rf and i-f stages amplify at their maximum capability.

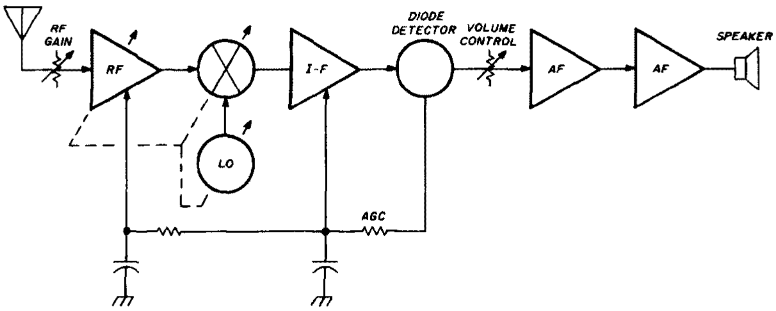


fig. 8. Block diagram of an a-m superheterodyne including an AGC circuit.

The result of this is that all signals, weak, medium, and strong, produce nearly the same signal strength at the output of the detector. As you tune across a band having several a-m signals on it they should all sound about the same strength to you if AGC is being used. This type of circuit is also referred to as automatic volume control.

More advanced a-m receivers may use a separate i-f amplifier to produce a greater and more effective AGC voltage in a circuit, somewhat as shown in **fig. 9**. The negative (or reverse bias) AGC voltage is not only fed to the i-f and rf amplifiers to control their gain, but also to an S-meter to indicate the relative strength of the signal being received. The stronger the signal the more AGC voltage and the higher the S-meter will read.

We have shown the rf, mixer, local oscillator, i-f, detector, and af stages as being separate identities. Today it is possible to use a special front-end integrated circuit (IC) and add only the tuning circuits to it, plus a few resistors and capacitors. A second IC can be used for the i-f and detector circuits, requiring only the addition of tuned i-f transformers, and another IC for the af amplifiers. It is also possible for one IC to provide the i-f detector and af amplifiers, reducing equipment size greatly.

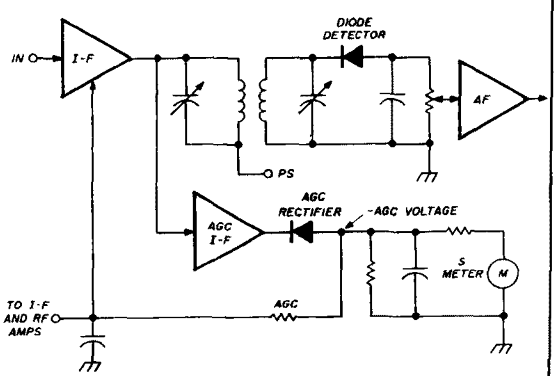


fig. 9. Diode second detector, with separate AGC and S-meter circuit.

FCC test topics

The following Novice class FCC test topics are discussed in this article:

- vacuum tubes, applications, symbols
- transmitter tune-up procedure
- undesirable harmonic output, cause and cure
- superimposed hum, cause and cure

The following Technician/General class FCC test topics are discussed in this article:

- amplitude modulation, overmodulation, splatter
- block diagram of complete a-m transmitter and receiver
- sidebands, double sideband, single sideband
- frequency mixing
- bandwidth
- transformer applications
- emission types AØ, A3, A3J
- use of field strength meter and S-meter

The following Advanced class FCC test topics are discussed in this article:

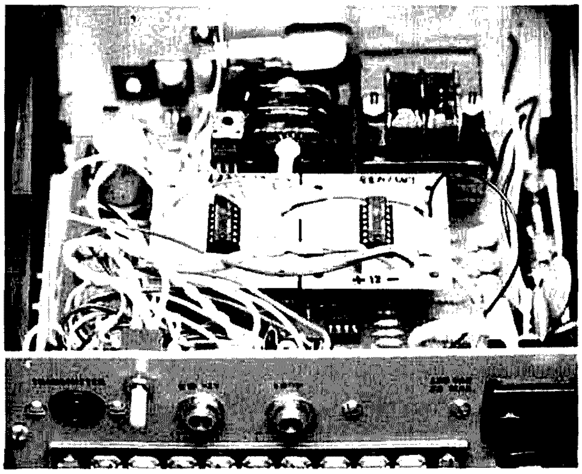
- modulators, a-m methods
- emission types, A3, A5
- oscillator applications
- transmitter final amplifiers
- detectors, mixer stages
- rf and i-f amplifier stages

For additional information on these subjects refer to *Electronic Communication*, or to *Amateur Radio Theory and Practice*, by Robert L. Shrader, W6BNB, McGraw-Hill Book Company, available through *Ham Radio*'s Bookstore.

ham radio

an RS-232 to TTL interface

Let your computer be your teleprinter



Interface circuit installed in Flesher TU-170 on prototype board in middle. Normal/ASCII switch selector is on the left side of rear panel.

With FCC approval of ASCII transmissions, more and more Amateurs are letting the dust collect on their teleprinters and are using their computers for RTTY or CW communication. If your computer or computer terminal has a standard RS-232 serial interface port, this circuit will allow ASCII through your RTTY Terminal Unit (TU).

This circuit was designed to work with a Flesher TU-170 and will work with any TU having TTL input/output. A National Semiconductor LM1488 line driver inverts the TU demodulator to Mark low at − 12 Vdc, Space high at + 12 Vdc for RS-232 input to the computer. The National LM1489 line receiver converts the computer output Mark to TTL high and Space to TTL low for keying the audio frequency shift input of the TU.

The Flesher provides regulated ± 12 Vdc but a 7805 + 5 Vdc three-terminal regulator was added for the LM1489. The 2200-ohm series resistors are for serial port protection and may be considered optional. All components mount easily inside the TU-170, as shown in the photograph. The DB-25 connector

By Bob Harvey, WD4KQI, 231 Winding Way Road, Lynchburg, Virginia 24502

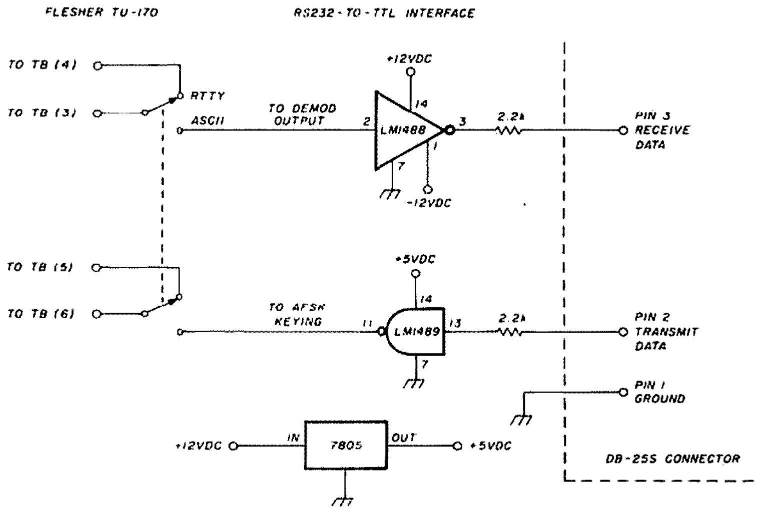
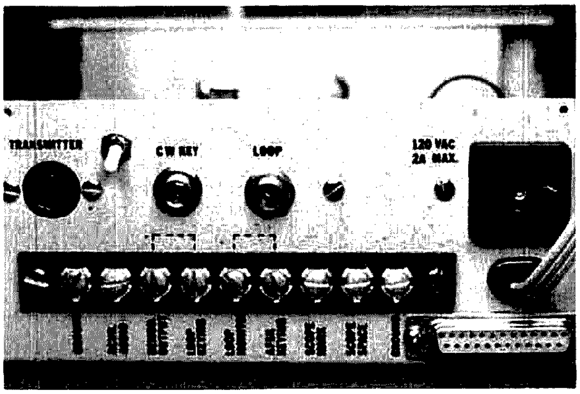


fig. 1. RS-232 to TTL interface.

quantity	*description*
1	*LM1488N, Jameco*
1	*LM1489N, Jameco*
1	*7805 +5 Vdc regulator IC, Radio Shack 276-1770*
2	*2.2K, ¼ watt resistors*
1	*dual IC board, Radio Shack 276-159*
2	*14 pin IC sockets, Radio Shack 276-1999*
1	*dpdt switch, Radio Shack 275-614*
1	*DB-25S connector, Jameco*



Rear panel of Flesher TU-170. Selector switch is between the transmitter and CW key connectors. DB-25 connector for serial input/output is on the bottom right. Note jumper markings on terminal board: internal jumpers must be removed for selector switch operation.

for the RS-232 interface mounts on the TU-170 rear panel.

The toggle switch allows the Flesher unit to operate normally or with the RS-232 interface. The Flesher TU-170 must be modified to pass the higher 110 baud ASCII rate: change C19, C20, and C23 from 0.01 μF to 0.005 μF and remove the two jumpers from TB(3) to TB(4) and TB(5) to TB(6).

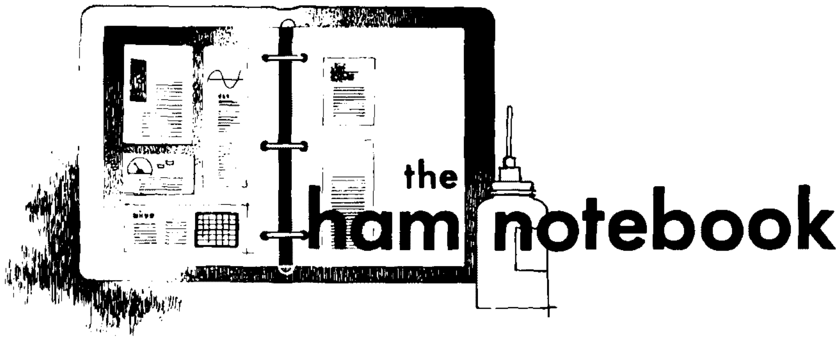
The computer must be initialized to 110 baud, with no parity, eight-bit word, two stop bits, and zero nulls. Some software may be required for serial communication and several companies provide hardware and software packages. Two companies providing ready-to-run packages for the TRS-80 Model III are Crown Micro Products and Macrotronics, Inc.

The Flesher TU-170 is a proven, reliable unit, but I have found it is susceptible to stray rf in the shack. The autostart may be tripped; a cure is to bypass the audio input at TB(2) to ground with a 150 pF capacitor. Ferrite beads on each terminal strip lead will help to keep out rf. The audio line from transceiver to TU should be shielded for proper operation of the terminal unit.

Only three pins of the RS-232 connector are required for TRS-80 to TU-170 interconnection. Other computers or terminal units may require more lines; the remaining three line drivers and receivers are unused and available.

This interface has been installed in other terminal units and it is a welcome relief to operate in relative silence, compared with the noise made by a teleprinter.

ham radio



trans-global power supply

The power supply in this design can supply solid state low-voltage requirements from a variety of input mains voltages, making it ideal for any equipment used internationally. It satisfies a 12 volt at 1 amp specification for a particular piece of equipment; by changing the voltage and/or current limitations of the components, it can be altered to suit your needs over a very wide range of input and output combinations.

The novelty in this design (see **fig. 1**) is the use of switch S1 to handle wide variations in input voltages while providing the desired output. S1 can be a physically actuated switch accessible to the user, or a leaf-type switch thrown automatically when the proper U.S. or non-U.S. (usually 220 Vac) cord is inserted into the back apron receptacle.

When the switch is in the 120 Vac position, the transformer operates with the full secondary voltage applied to a bridge rectifier system whose filtered dc output is fed to the regulator. In the 240 Vac position, the transformer is center-tapped, supplying the rectifier system with one-half the available transformer secondary ac voltage. The bridge becomes a full wave rectifier system, ignoring two of the diodes, and a dc filtered output in approximately the same voltage range as the 120 Vac position of S1 is fed to the regulator to obtain the same regulated dc output.

The supply may be re-designed by applying textbook design formulas to it. Use the higher voltage and current requirement each component part requires; this will satisfy all the requirements for dual input voltage use, but what of the variations found in international use?

The transformer may have to be a 50 Hz instead of 60 Hz model, to meet the more common 50 Hz mains frequency found in most countries. Many places may have only 105 Vac as the nominal voltage, or perhaps 200 Vac as a high tap input. The transformer, diodes, and filtering should be calculated to prevent the filtered dc feeding the regulator to drop below the regulation minimum dc input to the regulator device. On the other side of the coin, diode PIV rating, the ratings of filter capacitors, and the regulator maximum dc input limits will have to be watched carefully to allow headroom for countries with poor mains regulation or high-side mains input like 140 Vac or 260 Vac.

Switches used in the primary of a transformer must be rated for at least the mains voltage, which in international use can climb to as high as 260 Vac. By using a switch in the secon-

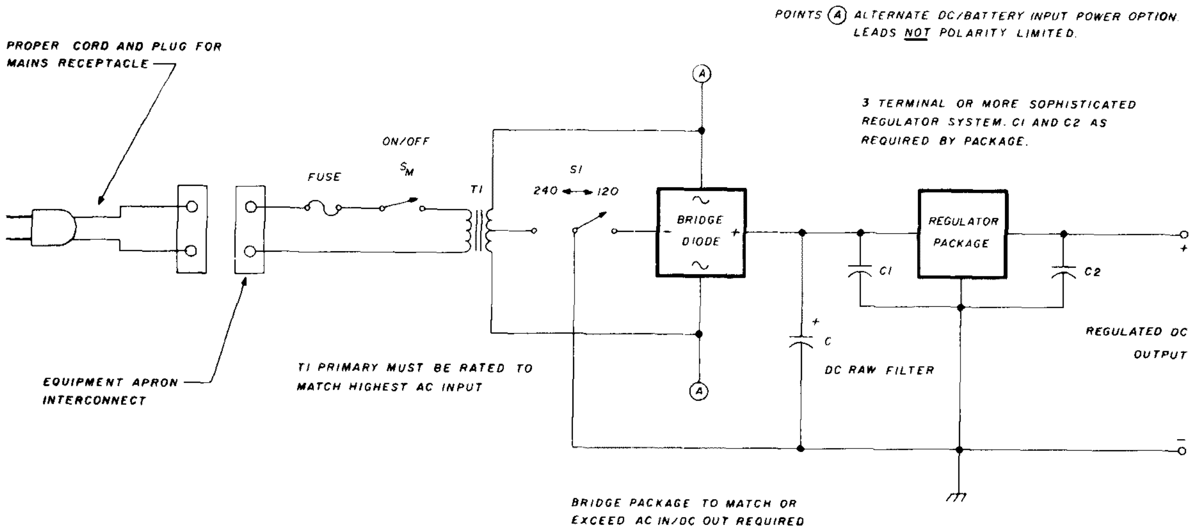


fig. 1. International power supply.

dary, and for most solid state dc requirements, that voltage can be much lower even when the switch is used at the ac secondary of the transformer, like S1. You have to remember the current requirement at that point is quite a bit higher than in primary uses, but the switches should still be easier to find, less expensive, and not need the UL and other higher-voltage requirements necessary in primary applications of switches.

David J. Brown, W9CGI

homebrew linears: treat or trap?

An account of a fatal disaster that killed a broadcast engineer some years ago made me wonder if a similar accident could happen to any Amateur. As I saw that indeed, it could, I decided to write this note to warn fellow Amateurs.

The original accident arose from a discontinuity between the main TX chassis and the high voltage B return from the power supply. This resulted in the TX chassis, cabinet, and antenna becoming *hot* at B+ potential.

A similar situation could easily occur with a homebrew linear equipped with a separate power supply. Consider the arrangement outlined in **fig. 2**. This shows the basic configuration of a tube linear, and power supply implemented on a separate chassis, a fairly common arrangement adopted by homebrewers (and by some commercial ones, too). Assume the builder adopts the usual practice and grounds the PS via the ac earth return, but omits, as many of us do, to connect a separate earth return to the linear chassis. Next, assume that the antenna and driving TRX are connected to the amplifier, and the big switch is turned on. The linear tubes light, drive is applied, and the appropriate plate voltage and current appears on the respective meters. All appears to be in order.

Suppose now that due to error or cussedness the B return has a discontinuity. Should our builder now disconnect the drive input coax, or perform some other operation that isolates the linear from a default earth return, he will find himself shaking hands with the full B+ as his body now provides the B− return to ground.

I leave it to the reader to work out the various combinations and circumstances that can lead to a similar result. The moral of the story is that because we tend to visualize current going to and coming from a device, we see any interruption of the to- or from-circuit as rendering the device inoperative and neutral. We fail to appreciate that decidedly unhealthy current can return via internal circuitry to make contact at a considerable potential with grounded objects like ourselves. In the case in question, the amplifier tubes provide the continuity for the B+ to the chassis and case, particularly as the separate filament transformer keeps the tubes lit and conductive.

Make certain you are not relying on just one wire and its associated contacts for the B return between the linear and the HT power supply. A better, but not absolutely fail-safe, method is to ground one side of the filaments at both ends of the connecting cable if these are supplied from the PS chassis. Another is to isolate the B minus on the PS side from the PS chassis. Alternatively, use a braided ground strap and bolt this to both boxes. Please check your homebrew devices and correct them accordingly, lest you become an untimely addition to the silent key list.

postscript

After writing this article, I took a look at the details of a number of linear amplifiers in the 1981 *ARRL Handbook*. All indicated only one return connection between the amplifier and the HT power supply. Filaments are invariably fed through a separate transformer with a non-earthed ac input. A check in the power supply section showed a 3400 volt supply offering a two-terminal output. The B− was grounded to the chassis and the ac input was shown as having a three-way plug input with the ground to chassis. Users of such a PS/linear-amplifier combination are only one pin connector away from a sudden end.

L.R. Newsome, VK4LR

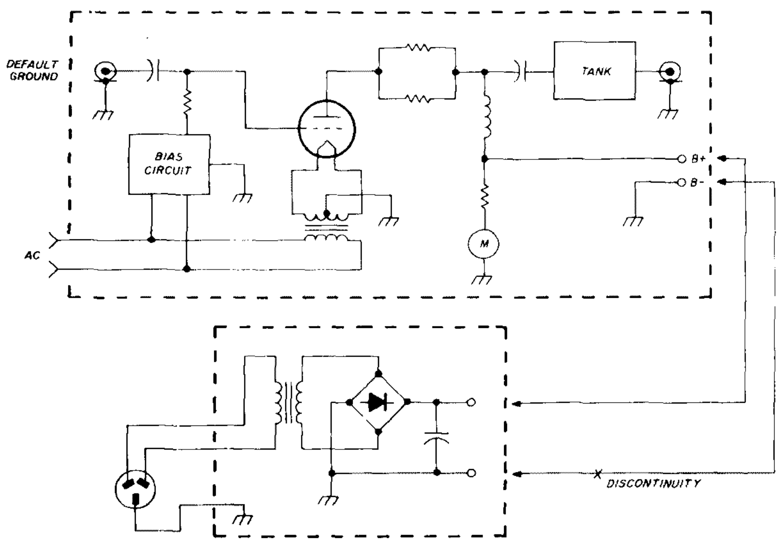


fig. 2. Tube linear with power supply.

$370 — I ship. WB6AWM/7, P.O. Box 251, Electric City, WA 99123.

KT5B Multi-Band dipole 160-80M (WARC) $59.95, 2KW plus center connector w/SO239 $8.50. Kilo-Tec, P.O. Box 1001, Oak View, CA 93022. (805) 646-9645.

MOTOROLA ALL SOLID-STATE MOTRAN RADIOS, Model X43LSN-2170, four frequency, transmit 150 MC (30W), receive 450 MC. Will operate in Ham Bands. No modification required. Large stock available. $150.00 each. Omni Communications. Call (312) 852-0738.

MOTOROLA VHF (2 meters) U43 Motran, 4 channel all solid state. Omni Communications. Call (312) 852-0738.

Coming Events

ACTIVITIES

"Places to go..."

ARKANSAS: The Arkansas DX Association's annual DX meeting and banquet, Saturday, December 4, Fort Smith Ramada Inn. Friday night mixer and hospitality suite for early arrivals. Saturday morning ADXA business meeting followed by a DX forum. Saturday afternoon Arkansas/Texas football party. Saturday evening banquet with a DX speaker of note. For information: Harold Wilson, KB5RF, 3507 Lochland, North Little Rock, Ark. 72116. (501) 753-8625.

MASSACHUSETTS: The Hampden County Radio Association's annual auction, Friday, November 5, Granger School, intersection of Routes 57 and 187, Feeding Hills. Doors open 7 PM; auction begins 8 PM. For more information: Dick Manner, N8BQU at (413) 783-9380.

MASSACHUSETTS: The Honeywell 1200 Radio Club, sponsor of 147.72/12 repeater and the Waltham Amateur Radio Association, sponsor of 146.04/64 repeater, will hold their annual Amateur Radio and electronics auction, Saturday, November 20, Honeywell Plant, 300 Concord Road, Billerica. Doors open 10 AM. Free admission and parking. Talk in on both repeaters. For more information: Doug Purdy, N1BUB, 3 Visco Road, Burlington, MA 01803.

MICHIGAN: ENCON Corporation together with SOLAREX Corporation will provide a FREE photovoltaic seminar (electricity from the sun), November 4, 7:30 PM, Dearborn Hyatt Regency, Dearborn. A talk on history, production of solar cells, and applications will inform and educate all those who attend. Call for reservations: Encon Corporation, 27584 Schoolcraft Rd., Livonia, MI 48150. (313) 261-4130.

MICHIGAN: The 17th annual Hazel Park Amateur Radio Club's Swap and Shop, Sunday, December 5, Hazel Park High School, Hughes St. at 9½ Mile Road, Hazel Park. Doors open 8 AM. Tickets $1.50 advance or $2.00 door. Plenty of food, parking, prizes. Tables $1.00 per ft. Talk in on 146.52. For tickets, table reservations, information SASE to Hazel Park Amateur Radio Club, P.O. Box 368, Hazel Park, MI 48030. (313) 398-3189.

NEW YORK: The Radio Central Amateur Radio Club's 1982 edition "Ham-Central", Sunday, November 28, main social hall, Temple Isaiah, 1404 Stony Brook Road, Stony Brook, Long Island, 50 miles east of NYC. General admission $2.00, XYL's and kids under 12 free. Doors open 8:30 AM. Prizes, refreshments, slide shows. Talk in on WA2UEC, 144.550/145.150 and 146.52 simplex. For advanced sellers' reservations: Scotty Policastro, KA2EOW, 80 - 7th Street, Bohemia, NY 11716 (516) 589-2557 and Bob Yarmus, K2RGZ, 3 Haven Court, Lake Grove, NY 11755 (516) 981-2709

PENNSYLVANIA: The Foothills ARC annual Swap and Shop, November 6, St. Bruno Church, South Greensburg. Indoor flea market, prizes. Talk in on 146.07/67 and .52/.52. For information: Mario, W3TTN or write FARC, P.O. Box 236, Greensburg, PA 15601.

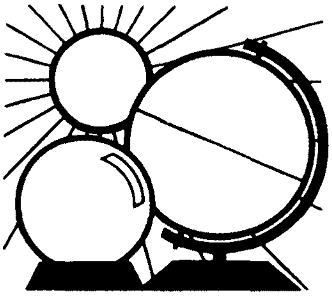
OPERATING EVENTS

"Things to do..."

DECEMBER 11: The K1BCI C/Q Radio Club will operate a special event station honoring the 35th anniversary of the Christmas Village in Torrington, CT. The club will operate from Christmas Village on 10, 15, 20, 40 and 80 meters, December 11 through 19. Certificates will be issued for contacts made. For information: Jim, WA1YZA or Nellie, WB1DVC.

JANUARY 15: The Potomac Valley Radio Club is sponsoring the United Nations World Communications Year contest from 0001 UTC to 2400 UTC, Saturday, January 15, 1983. The object of the competition is to stimulate interest in communications development. For more information SASE to Potomac Valley Radio Club, P.O. Box 337, Crownsville, MD 21032.

More Details? CHECK—OFF Page 102



DX FORECASTER

Garth Stonehocker, KØRYW

wintertime DX

November comes long enough after the fall equinox to begin wintertime DX. Usually most of us stay closer to home, pursuing indoor activities. Except for a little time spent outside putting finishing touches on new antennas or making winterizing repairs on old ones, the warmth of your shack feels just right. The wintertime DX season's advantages help make it a time of enjoyment, too. The sun, shining more in the southern hemisphere, lets signals escape from some daytime attenuation so lower-powered DX can reach us. The QRN noise from spring, summer, and fall thunderstorms decreases as fewer local thunderstorms pass through and the large thunderstorm areas near the equator move further south. The decrease in noise is particularly noticeable on the 160, 80, and 40-meter bands.

Another plus is that November is often specially significant because of the quiet conditions of the geomagnetic field. November and December are the quietest months of the year. By quietest *I* mean the increased steadiness of the magnitude and direction of the magnetic field, as measured at any selected point by a magnetometer (a very sensitive compass). See this column in *ham radio*, November, 1981, for more on geomagnetic variations.

The long hours of winter darkness allow the ionosphere to decay for an extended period after the midday peak. The long decay time leaves little ionization, and good DX on the lower-frequency bands becomes possible. Hence, 160 meters (our lowest frequency band) is a good bet for late night and early morning DX fun. This deep daily pre-dawn minimum contrasts with the maximum useable frequency's steep rise to a high value (almost as high as in the equinox periods) each day with the sunrise. The MUF and depth of the pre-dawn dip are related to the solar flux each day.

Plenty of meteor showers will be occurring from October 26 to November 22, with a maximum count of ten per hour from the third through the tenth. This shower is known as the Taurids. Lunar perigee is on the fourth, and full moon falls on the first.

last-minute forecast

The high-frequency bands, 10 through 20, will be the best DX bands the first and last weeks of the month. That will make the Thanksgiving holiday a good weekend for DX. The lower frequencies will be best for the middle of the month, although not too bad all month long. Geomagnetic disturbances may be expected around the fourth and twenty-first from solar flares and near the twelfth from coronal hole activity. Have a good holiday.

band-by-band summary

Fifteen meters will be open for F2 long skip by the trans-equatorial one-long-hop propagation. Openings should be frequent. Worldwide DX is prevalent from after sunrise until well after sunset, especially during the periods of high solar flux. (Listen to WWV at 18 minutes after the hour for reports on solar and geomagnetic conditions.)

Twenty meters will be open most days and nearly through the night to some areas, with long skip of 1000-2500 miles and some short-skip of 1200 miles near midday. Both propagation modes follow the sun across the sky: east, south, then west.

Forty meters is the transition band, with all-night propagation as well as some short skip during the day. Most areas of the world can be worked from darkness until just before sunrise. Hops shorten to about 2000 miles on this band, but the number of hops can increase since signal absorption is low during the night.

Eighty meters is traditionally a ragchewer's band, but DX is also possible. The band operates much like 40 meters, except the hop distances shorten to around 1500 miles at night and shorter during the daytime. Noise is so low this band is a joy to work during this time of year. The path direction follows the darkness across the earth (east, south, then west). You'll have to wiggle in between the QRM, however.

One-sixty meters will be like 80 meters, with skip range reduced to 1000 miles. It will provide good DX for late night and early morning DXers. The new band power and unrestricted areas should increase activity.

ham radio

NOVEMBER

WESTERN USA

GMT	PST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	4:00	10	20	15	10	15	10	10	15
0100	5:00	10	20	15	15	15	10	10	15
0200	6:00	15	20	15	15	15	10	10	15
0300	7:00	15	20	20	15	15	10	10	15
0400	8:00	20	40	20	15	15	15	15	15
0500	9:00	—	40	20	20	15	15	15	20
0600	10:00	—	—	20	20	20	15	15	20
0700	11:00	—	—	20	20	20	20	15	20
0800	12:00	—	—	20	20	20	20	20	40
0900	1:00	—	—	20	20	20	20	—	40
1000	2:00	—	—	20	40	20	40	—	40
1100	3:00	—	—	—	40	20	40	20	40
1200	4:00	—	—	—	40	40	40	40	40
1300	5:00	—	—	—	40	40	40	40	—
1400	6:00	—	20	—	20	—	40	40	—
1500	7:00	20	20	20	15	—	40	20	—
1600	8:00	20	20	15	15	—	40	15	—
1700	9:00	20	15	15	15	—	15	15	—
1800	10:00	20	15	15	15	15	15	15	—
1900	11:00	15	15	10	10	15	10	15	20
2000	12:00	15	20	10	10	15	10	15	15
2100	1:00	15	20	15*	10	15	10	10	10
2200	2:00	15	20	15*	10	15	10	10	10
2300	3:00	15	20	15	10	15	10	10	10

MID USA

GMT	MST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)	CST
0000	5:00	15	20	15	15	15	10	10	15	6:00
0100	6:00	15	20	15	15	15	10	15	15	7:00
0200	7:00	15	20	20	20	15	15	15	15	8:00
0300	8:00	20	20	20	20	15	15	15	20	9:00
0400	9:00	—	40	20	20	15	20	15	20	10:00
0500	10:00	—	40	20	20	15	20	20	20	11:00
0600	11:00	—	40	20	40	15	20	20	—	12:00
0700	12:00	—	40	20	40	20	20	20	—	1:00
0800	1:00	—	40	—	40	20	20	20	20	2:00
0900	2:00	—	40	—	20	20	20	20	20	3:00
1000	3:00	—	40	—	40	20	—	—	20	4:00
1100	4:00	—	—	—	40	—	—	—	20	5:00
1200	5:00	20	—	—	20	—	—	—	—	6:00
1300	6:00	20	—	—	20	—	—	—	—	7:00
1400	7:00	20	20	—	15	—	—	—	—	8:00
1500	8:00	20	20	10	10	—	—	20	—	9:00
1600	9:00	20	15	10	10	—	20	15	—	10:00
1700	10:00	20	15	10	10	—	20	15	—	11:00
1800	11:00	20	15	10	10	—	20	15	—	12:00
1900	12:00	20	15	10	10	—	15	15	—	1:00
2000	1:00	—	20	15	10	—	10	15	20	2:00
2100	2:00	—	20	15	15	—	10	10	15	3:00
2200	3:00	—	20	15	15	15	10	10	10	4:00
2300	4:00	—	20	15	15	15	15	10	10	5:00

EASTERN USA

GMT	EST	N (Asia Far East)	NE (Europe)	E (S. Africa)	SE (Caribbean S. America)	S (Antarctica)	SW (New Zealand)	W (Oceania Australia)	NW (Japan)
0000	7:00	15	20	15	15	15	10	10	15
0100	8:00	15	20	20*	20	15	15	15	15
0200	9:00	—	20	20	20	15	15	15	20
0300	10:00	—	20	20	20	15	15	20	20
0400	11:00	—	20	20	20	15	20	20	20
0500	12:00	—	40	20	20	20	20	20	20
0600	1:00	—	40	20	20	20	20	20	20
0700	2:00	20	40	20	20	20	20	20	20
0800	3:00	20	40	40	40	20	20	20	20
0900	4:00	20	40	40	40	20	20	20	—
1000	5:00	—	—	40	40	—	40	—	—
1100	6:00	—	—	—	40	—	80*	—	—
1200	7:00	—	—	—	20	—	—	—	—
1300	8:00	—	—	10	20	—	—	—	—
1400	9:00	20	15	10	10	—	—	—	—
1500	10:00	20	15	10	10	—	—	15	—
1600	11:00	15	10	10	10	—	20	15	20
1700	12:00	15	15	10	10	—	20	15	20
1800	1:00	10	15	10	10	—	15	15	—
1900	2:00	—	15	10	10	—	15	15	—
2000	3:00	—	15	10	10	—	10	15	20
2100	4:00	—	20	10	15	15	10	15	15
2200	5:00	—	20	15	15	15	10	10	15
2300	6:00	—	20	15	15	15	10	10	15

*Look at next **higher** band for possible openings.

calculator or computer — which to buy?

An outline of the capabilities of today's machines

This article is for the ham who has computational work to perform. It's intended to help answer the question, Should I buy a personal computer? If not, should I stick with my calculator, or maybe get a better one? To answer this, we'll need to look at the problems to be solved, the capabilities of calculators and computers, and factors of cost and time.

Let's assume that three types of calculators and three sizes of computers are being considered. For the calculators, these are:

- a small "four-function" calculator with four-function memory;
- a "scientific" or "slide rule" calculator, with twenty to twenty-five functions and addressable memory;
- a programmable calculator, with some dozens of memory locations and one hundred to two hundred program step capacity, with loop and decision capability.

For the computer, let's assume the following types, each with average memory:

- a "pocket" or "book" computer, with Basic and at least some scientific functions;
- a "single package" expandable computer, with TV screen and a keyboard;
- an expanded computer with a disk memory and two internal languages.

The calculator costs will be about $10, $35, and $200, and the computer costs will run about $175, $350, and $2500. More can easily be spent on the top calculator and on any of the computers. Cost will obviously be an important element in the decision.

Let's look at these possibilities with respect to problems to be solved. Let's say that the first problem is a receiver design, where the tuning inductor is to be worked out. And, to give an idea of impedance levels, we decide that the reactance should be calculated. The pertinent equations are:

$$X_C = 1/2\pi fC = X_L = 2\pi fL$$

where, given C, you determine X and L.

The little four-function calculator handles this nicely, with a few keystrokes and ample accuracy. So do the other calculators. If the computers have a proper Basic, they can be used as calculators in the direct execution mode, but with a few more key strokes (the relation is entered without the line number, causing immediate execution on carriage return — the answer may need to be recalled with a separate operation). At this level of problem, the larger calculators and the computers are somewhat more likely to cause a keystroke error, but otherwise, all calculators and computers can be considered usable.

However, suppose we are working on a new nine-band superhet with rf stage. Now the problem must be repeated twenty-seven times. The two smaller calculators take twenty-seven times as long, with the slide-rule type no better than the smallest. But a small program can be written for the programmable calculator and the computers, so that only the data need be entered. And some programming "tricks" can be introduced, such as the fact that the local oscillator differs from the rf by the i-f frequency, simplifying data input.

It is apparent that the number of calculations and the time available for doing them will both have an important bearing on your choice. If such problems don't come up too often, and there is plenty of time for them, the low-cost way is all right.

There is another consideration here. For these basic calculators and computers, it is necessary to

By R.P. Haviland, W4MB, 2100 S. Nova Road, Box 45, Daytona Beach, Florida 32019

pause after each value of inductance is read, copy it on paper, check the recorded value, then proceed. It would be much easier to have the results printed. This is possible, at a price.

Printing versions of the smallest calculator are available at an incremental cost of $30 or so. But there isn't a single slide-rule calculator with print capability on the market until you reach the top calculator line. And here the incremental cost is likely to be nearer $200. This is about the minimum cost of any computer printer, although small printers are becoming available at about half this cost. But full printers run $500 to $5,000 — often as much as a computer.

This is an important point. How important is printout to you? And how much do you need page production versus single-column prints? And how much will these cost?

Let's look at another problem. Suppose you are considering a new 80-meter antenna, and decide to look at an array of phased verticals. The space you have available doesn't allow a standard square, so you want to calculate patterns of some possibilities.

The basic equation to be solved is simple,

$$e_{\theta,\phi} = f_n(\theta)\,(1 + k_n e^{ja_n})$$

(see *ham radio*, May, 1977, page 79)

but the k_n involves a ratio of currents and the a_n the spacing between antennas, their phase, and the direction being calculated. For a vertical, there are four quantities to be handled for each antenna. And for each 10 degrees or so there is a calculation, typically out to 180 degrees of angle.

Because this equation involves sine and cosine functions plus polar to rectangular coordinate conversion, forget the smallest calculator — you can do better graphically. And for some of the slide rule calculators, be prepared for tedious coordinate conversion. For others, it's built in. Solution is easy for a programmable calculator, but tricks may be necessary for one with small storage.

The solution should be no problem with any of the computers. But the results will have to be hand copied with the smaller, unless a printer is added. The two larger computers do have an advantage, in that the pattern can be displayed. This is good for preliminary study, and can be photographed, or duplicated on a page printer.

If there aren't too many of these problems, the better slide-rule calculators would be all right. But there is a strong urge to go first class — at least a programmable calculator, with plenty of registers and a printer, or one of the computers with a printer.

For a final problem, let's look at the series of Yagi antenna articles by W2PV, published in *ham radio* in 1979 and 1980. The first article gives the relations used. They aren't really difficult, and all but the simplest calculator can handle the calculations. But look at the amount of calculation involved. A single point on the curve involves matrix inversion, with complex numbers, and from two to nine unknowns. A single curve might require ten or so such runs, and there are hundreds of curves. Unless there is a lot of memory, and a curve plotter available, the work load is atrocious. And this gives a bias to the largest computer, with plenty of expansion capability.

Let's insert a caution here. Problems of this type can be solved by simple means, even by pencil, paper, and a set of trig and log tables. For example, see *Tables of Functions* by Jahnke and Emde for plots which are even better than can be generated by computer. The major ingredients needed are time and dedication.

Let's put these points in summary form. If you are on a tight budget, stay with calculators. Probably you will want a slide-rule type, preferably with addressable memory. And be prepared to spend time on the larger problems. And hope that some manufacturer brings out a matching, low-cost printer.

If the budget is less tight, you'll need to choose between a programmable calculator and a small computer. To make a decision, it seems that you'll have to examine the size and type of problem you expect in some detail, and also the way you approach problems. At this time the expandable programmable calculator seems best if you have problems of any complexity, but the small computers are developing rapidly, so look them over carefully.

With essentially no budget limitations, the choice falls between the top of the line programmable calculator and an expanded computer. As far as calculation capability goes, there isn't much difference between them. The computer can have more memory, making larger and repetitive problems easier to handle. Also, a page printer is better for organizing data for presentation, making plots and even writing reports. But don't expect to get all of this capability for free. You'll have to buy a lot of accessories and programs to run them, or spend a lot of time on hardware and software development. And don't forget that the top computer considered here costs around ten times as much as the top calculator.

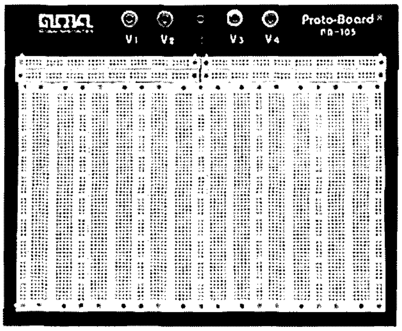
To complete the evaluation, we should note that there can be a bias factor in the decision. If you are interested in computers as such, and like either hardware or program development, this puts a strong bias on going to a computer. But if you just want to solve problems, the calculator has to be considered. It is almost certainly the less expensive way to go, and for you, it may be the best way.

ham radio

NEW products

solderless breadboard with more working area

The new PB-105 solderless breadboard from Global Specialties Corporation contains five binding posts, eighteen distribution buses and six solderless breadboarding sockets. The 9.2 × 11.4 × 0.05 inch (234 × 290 × 1.3 mm) superboard, designed for microprocessor applications, of-



fers fifty percent more breadboarding area (up to 48 14-pin ICs) than the next smaller size.

The solderless breadboard assemblies combine quick test socket and bus strip elements on sturdy aluminum backplates. Breadboard elements are screw-mounted from beneath the backplate. Red binding posts are electrically insulated from the backplate while the black binding post is electrically connected to the metal backplate (ground plane).

Other specifications for the PB-105 include: sockets, six QT-59S; bus strips, four QT-47B, seven QT-59B; IC capacity, 48 14-pin DIP 912 terminals; 4560 tie points; binding posts, five five-way binding posts; #22 AWG wire size preferred, 0.01-0.033 inch (0.25-0.84 mm) diameter component leads acceptable, 0.015-0.032 inch (0.38-0.81 mm) recommended; resistance — initial contact resistance is less than 0.5 milliohms, reduces to less than 0.04 milliohms after multiple insertions.

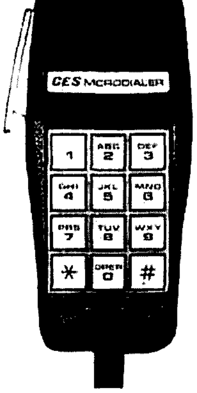
Proto-Board assemblies are engineered for use in design, text fixturing, quality control, prototyping, evaluation inspection and custom circuit applications. The suggested price is $115.50.

For more information, contact Globe Specialties Corporation, P.O. Box 1942, New Haven, Connecticut 06509-1942; telephone 203-624-3103.

one-handed mobile mic dialing

Communications Electronics Specialties introduces its CES 635 Microdialer. The CES 635 incorporates the mike element and the Touchtone buttons on the same side of the microphone, and features a programmable pause that allows the operator to bring up the patch, pause, and dial the telephone number by pushing two buttons. It also keys the PTT line prior to sending the first tone so that nothing is lost in the transmission.

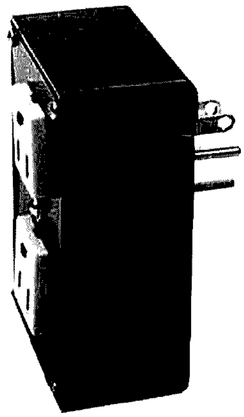
The CES 635 Microdialer also features ten programmable memories. The first five memories hold up to eleven digits, while memories 6-0 hold up to seven digits. Dialing speeds from one to eight digits per second can be programmed.



For more information, contact Communications Electronics Specialties, Inc., P.O. Box 507, Winter Park, Florida 32790; telephone 305-645-0474.

wall socket pollution control

Power-line electrical noise, hash, and spikes often cause erratic transmission or poor reception. In addition, severe spikes from lightning or heavy machinery may damage expensive hardware.



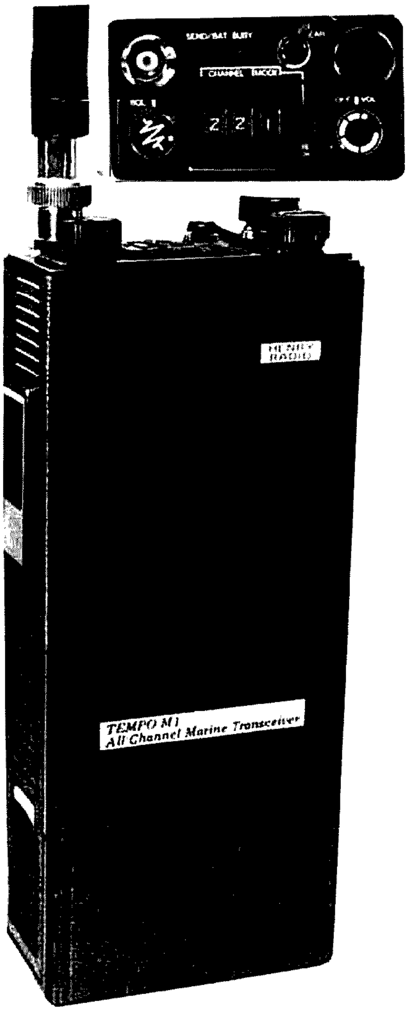
Electronic Specialists' new Direct Plug Super Filter and Suppressor features a dual-pi filter to control electrical pollution. A 6500-ampere spike/surge suppressor protects equipment from damage caused by lightning or heavy machinery spikes.

Direct Plug Super Filter pollution control and equipment protection is available for $55.95 (Model DP-SF/T-32).

For more information, contact Electronic Specialists, Inc., 171 S. Main St., Box 389, Natick, Massachusetts 01760; telephone 617-655-1532.

Tempo marine portable

Henry Radio introduces a new marine VHF band portable, the Tempo M1. Other transceivers operate on only six to twelve channels, but the new M1 operates on every marine channel, both U.S. and international, with all the necessary offsets built-in. It also includes all weather channels and a channel-16 override function. Channel selection is made by a thumbwheel switch on the top panel. Simply dial up the channel number; no crystals to change, no internal adjustments.



Other special features designed into the M1 include a one-hour quick-charge-type battery with built-in overcharge protection. The battery pack is a professional, twist-off type. Each unit is supplied with rechargeable Ni-Cd battery pack, a rubber flex antenna, and full marine band, all channel programming.

Circuit design features include permanent memory programmed into a microprocessor controller for easy service and operation. The receive audio is extraordinary in volume and quality for a portable. Standby current is below 25 mA, insuring long battery life. It also includes a high-power 2-1/2-watt position and a low power 1-watt position.

For more information, contact Henry Radio Marine Div., 2050 S. Bundy Drive, Los Angeles, California 90025; telephone 213-820-1234.

Z-80 microcomputer kit

The Z-80 microprocessor has had a successful existence for many years. The microcomputers designed around the Z-80 have provided an excellent choice for the business-oriented user. However, till now there has been no economical system that would meet the needs of students, teachers, and experimenters who wished to evaluate the performance of the Z-80.

Carefully designed for maximum versatility, the PRO/80 includes an S-100 bus allowing the user to expand his system at will by choosing from various modules already available on the market. Extra wire wrapping space has been left for experimentation and the building of process control circuits on the prime circuit board. The PRO/80 also has two parallel input/output ports permitting access to external peripheral equipment. These two ports possess eight bits each, and each bit can be controlled by software. These ensure the user control of sixteen individual lines for particular applications. An interface for an audio cassette provides the user with an economical means of

NEW products

recording programs and data directly on tape.

The PRO/80 memory is one kilobyte of RAM, expandable on the board to two kilobytes. A third kilobyte of EPROM contains the monitor which performs several powerful functions such as memory examine and change, register examine and change, next memory location, next alternate register and a single step operation mode that provides the user with the capability to execute and debug programs one instruction at a time. Other functions such as reset, program execute, and cassette read-write are also featured on the PRO/80 monitor.

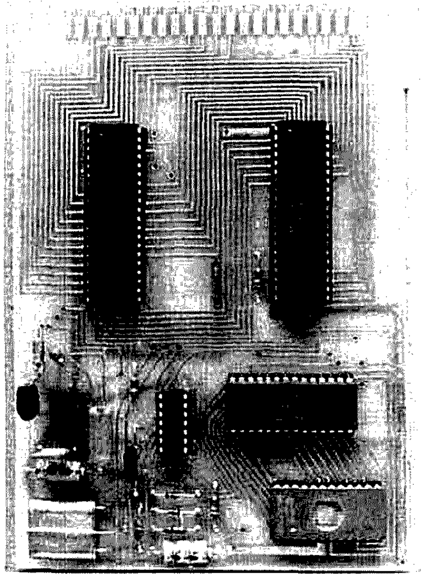
A hex keyboard with an additional eight keys is used to load data and programs and to initiate the different functions of the monitor. Six "seven segment" digits are used to display the memory addresses, the Z-80 registers, the alternate registers and their contents.

The PRO/80 requires only an 8-volt, 1-amp transformer to supply the required voltage. Complete instructions are supplied so that the kit can be built in a minimum amount of time, even by the novice constructor. A four-chapter manual is supplied to give the user additional information regarding use, construction, and operation of the PRO/80. This unique kit is available from ETCO Electronics, Plattsburgh, New York 12901, and is priced at $169.95.

For further information, contact Ted Duskes, ETCO Electronics Corp., Plattsburgh, New York 12901; telephone 514-342-1555.

Morse decoder

This Morse decoder automatically adapts to speeds from 2 to 80 WPM without any manual adjustments. "TAIMD" provides ASCII serial (110



Baud) and parallel outputs, plus dash/dot ratio (from 2 to 6.3) as well as calculated speed. Other outputs are strobe, two format controls for video terminals, and error signal.

NMOS microelectronic circuitry is compatible with low power TTL, and requires only 5 Vdc at 3/10 amp. Onboard PLL can be connected to receiver speaker terminals or earphone jack. Alternative input accepts contact-closure (key). Symbol set includes English alphabet plus foreign characters, digits, punctuations, and procedural symbols. Delivery is stock to 2 months.

For more information, contact Telecraft Laboratories & Company, P.O. Box 1185, East Dennis, Massachusetts 02641.

receiver kits

Three new VHF and UHF receiver kits have been designated with model numbers R144 for 143-150 MHz, R220 for 213-233 MHz, and R451 for 420-470 MHz. They cost $119.95, no more than previous top-of-the-line receivers.

Built on a single, compact pc board, the new receivers include volume and squelch controls mounted on the board for easy wiring. Sharp

NEW products

front-end filters reduce intermod and dense problems in demanding applications; the VHF receivers have a three-section helical resonator in the front end, the UHF version has a six-section tuned-line filter. I-f filtering utilizes both an eight-pole crystal filter and a ten-pole ceramic filter for a very sharp ±12 kHz bandwidth at 100 dB down. Automatic frequency control compensates for off-frequency transmissions.

Both receivers provide for an optional crystal oven with proportional heater to provide 2 PPM stability over a −30°C to +60°C temperature range (−22°F to +140°F). Hysteresis is provided in the squelch circuit to lock onto fading mobile signals. Sensitivity for 12 dB SINAD is only 0.15 μV for the R144 and R220 and .025 μV for the R451.

For further information, write Hamtronics, Inc., 65 Moul Road, Hilton, New York 14468-9535; telephone 716-392-9430.

Code Class

Macrotronics has announced the introduction of Code Class, a Morse code tutorial for the TRS-80 Model I or Model III microcomputer. Code Class is a machine language program written by licensed hams who understand the problems of learning Morse code. It is simple to use and exceptionally effective. Unlike the traditional Morse tapes and records, Code Class is interactive and presents code in a variety of formats in nonrepetitive sequences at adjustable speeds.

For the newcomer, there is a code tutorial that assumes no previous knowledge of Morse code. It is divided into eleven lessons. Each of the lessons teaches only four characters and may be repeated as often as necessary. Lessons combine both easy

and hard characters so that the whole alphabet is learned quickly.

The code practice portion of Code Class is designed to increase your speed and accuracy in copying Morse code. The program randomly generates a page of text, either random words, random characters or random ham callsigns; then it transmits the characters. After a page of text has been sent, the program stops to let you check the accuracy.

When coupled with a Macrotronics ham interface, Code Class will copy hand-sent code. The Morse receive algorithm in Code Class is excellent at receiving hand-sent code. The exact characters received will be displayed on the video monitor. Code Class requires a TRS-80 Model I (16K, level II BASIC) or Model III (16K, Model III BASIC). To receive Morse code, add a Morse code key and a Macrotronics ham interface (M80, M83, CM80, CM83, TM80, TM83, or TERMINALL). Specify cassette ($29) or disk ($39) Model I or Model III version.

For more information, contact Macrotronics, Inc., 1125 N. Golden State Blvd., Suite G, Turlock, California 95380; telephone 209-667-2888.

1/4-wave whip for handhelds

Centurion has introduced a new 1/4-wave straight whip antenna for use with handheld radios. The whip is 17-7 PH stainless steel with high-gloss black PVC coating. The base is fitted with a BNC connector.

The antenna is available in standard frequency ranges and factory-tuned to discrete frequencies from 118 MHz to 512 MHz. Approximate length for 2 meter band is 19.5 inches. The advantages of the new antenna, designated Model W, are higher efficiency and greater durability.

For more information, contact Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501; telephone 402-467-4491.

DECEMBER 1982 / $2.50

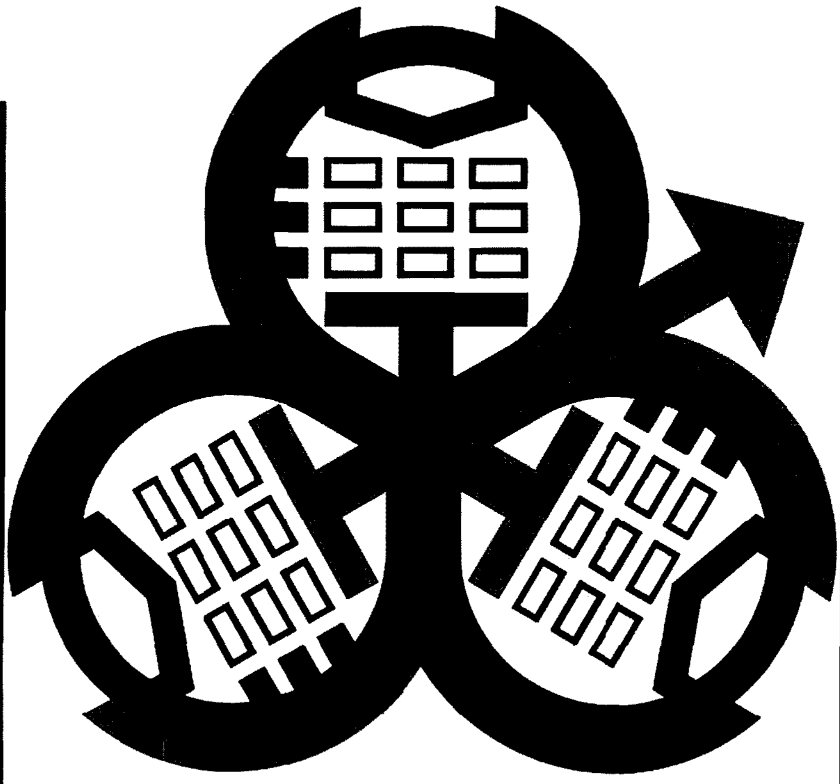
ham radio magazine

DECEMBER 1982

- improved TouchTone™ decoder
- rotary dial and encoder
- 40-meter transmitter-receiver
- data bandwidths compared

hr

focus on communications technology



low-cost LINEAR DESIGN AND CONSTRUCTION

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contents

REFLECTIONS

I must share this with you. I must blurt this out before I bust. We at *ham radio* magazine are so pleased with the turn of events and even more importantly with our glimpse at the future: a larger staff, a very welcome increased advertiser response (it's nice to be adding pages in groups of eight at the last minute), and so very importantly, your response to us. Yes, all the letters will be answered, the many article suggestions considered and encouraged. **Reflections** is our attempt at looking in both directions, remembering the past technical excellence of our hobby, individuals, and industry, while keeping an eye toward the future.

I feel very fortunate to be able to address so large a group of technical and knowledgeable individuals through this page and am taking the opportunity to throw out to the "floor" possibly the first question of our new technical forum section. The problem: *Normal communications channels down.* A fine gentleman, while honorably serving his country, suffered a wound that resulted in Padget's disease. For those not familiar with it, this is a progressively degenerative bone malady. Fortunately, through modern medicine, its destructiveness has been arrested. However one quite intelligent human being with a fine mind is now deaf and almost totally blind. The two normal means of communications that most of us take for granted — seeing and hearing — are "down." But his speech is excellent and his ability and desire to learn new techniques are great. They are surpassed only by his desire to carry on normal communications. I might add that his memory is outstanding. He knows the Morse code (from army days) and he has very slight shadow vision. Are techniques available (such as aural to tactile converters, aural to light converters and so forth) that can be used to provide faster inputting under these circumstances? I am aware of articles on this subject that have appeared in some of the ham magazines. Do any of our readers know of, or have ideas for, other techniques that might help?

Presented below is a preview of some of the subject areas *ham radio* magazine will cover in 1983. Please feel free to respond with your suggestions for additions or changes:

Antennas	*Phased verticals*
Filters	*Preamplifiers*
Future technology	*Propagation*
Ham computers	*Receivers*
Ham towers	*Repeaters*
Oscillators and synthesizers	*RFI*

Two thousand miles of almost non-stop driving during my move from Denver, Colorado, to join *ham radio* in Greenville, New Hampshire, gave me plenty of time to reflect on and appreciate another wonderful aspect of ham radio, the ability to communicate with a cross-section of Amateurs from Salinas and Topeka, Kansas; Kansas City and St. Louis, Missouri; Indianapolis, Indiana; Zanesville, Ohio; Wheeling, West Virginia; Pittsburgh and Scranton, Pennsylvania; through Binghamton, New York — to name a few. The miles melted away with the good company provided by local hams as we discussed everything from lightning protection for highly exposed repeaters to elaborate test procedures for squeezing out that last tenth of a dB in a high-gain Yagi array. There is real joy in hearing a warm voice coming from the 2-meter transceiver telling one very weary driver that there are motels just ahead where a late arrival might find a welcome bed. How I appreciated each transistor, resistor, and capacitor in my mobile unit, the repeaters I worked through, Maxwell's equations, and, most of all, the operators and technicians who made it all possible. To the many Amateurs I talked to during this recent trip, a hearty thank you.

Rich Rosen, K2RR
technical editor

comments

BCD addition/ subtraction

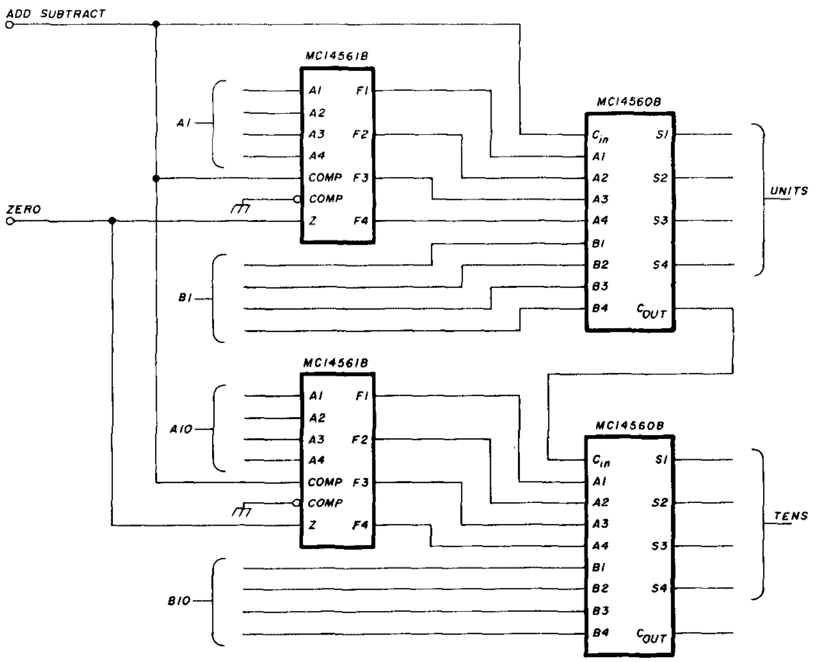
Dear HR:

After reading the April issue of *ham radio*, I would like to comment on the Ham Notebook item by Mr. Foot, WA9HUV. He is not alone in his desire for a method of BCD addition/ subtraction. However, Motorola already solved this problem many years ago with the introduction of a chip pair combination, the MC14560B and the MC14561B. The first is an NBCD adder and the second is a 9s complementer.

Connecting the units as shown in the data sheets (and reprinted in **fig. 1**) permits the user to choose a thumbwheel-selected number to program his synthesizer, or shift the number a fixed amount plus or minus. This feature is useful for setting a frequency source at a particular channel and then being able to shift its output to the upper or lower sideband.

The approximate cost per BCD digit is $5.40 in unit quantities. It's a slightly more expensive approach, but one that does not require clocking and can be easily cascaded. For further reading and more application assistance, I would recommend Motorola's application note AN-738, which covers the subject more completely.

Jeffrey L. Schiffer, Pres.
Phasetec Corporation
West Peabody, Massachusetts



TRUTH TABLE

ZERO	ADD/SUBTRACT	RESULT
0	0	B plus A
0	1	B minus A
1	x	B

x = DON'T CARE

fig. 1. Connections for an NBCD adder and 9s complementer allowing a thumbwheel selected number or a number shift of a plus or minus fixed amount.

quad versus Yagi

Dear HR:

Quad lovers awake! We are again being attacked by the Yagis (*ham radio*, May, 1982, "Quad Owner Switches"). It is not immediately apparent that the quad was given a fair shake by the test procedure. For example, a five-element Yagi on a 32-foot boom is matched up against a three-element quad on a 27-foot boom on 20 meters. On 15 meters a five-element Yagi was up against a four-element quad. On 10 meters, where the correlation is best except for the reversal of directivity, the match is five versus five.

The next problem I had was whether there were any matching devices at the antennas. Were baluns used, were their losses equal, was each antenna delivering maximum power to the line?

What bugs me most is that the authors took boom height as a reference height for both the quad and the Yagi. If the quads were fed at the center of the lower element, that point should be taken as the height of the quad. This would put the current loop for each antenna at the same height. It would seem that the procedure used in the tests handed the Yagi a height advantage on the order of 12 feet on 20 meters, 9 feet on 15 meters, and 6 feet on 10 meters. This would be expected to affect the vertical angle of the main lobe of the quad. Some Amateurs have advocated feeding the center of the upper element of the quad to improve the gain. Of course, there is a current loop in each of the horizontal elements if they are fed, but the loop at the feedpont will be greater.

C'mon home, guys. Wouldn't you rather fight than switch?

Howard B. Mouatt, W6BQD
Palm Desert, California

presstop de W9JUV

"CQ 30 METERS" HAS FINALLY BECOME A REALITY for U.S. Amateurs. FCC Commissioners voted October 28 to grant "temporary access" to the new band. Acting on a suggestion made by Senator Barry Goldwater, K7UGA, in an August letter to Chairman Mark Fowler (October Presstop), the Commissioners permitted General class and above to use 250 watts input, narrowband (CW and RTTY) modes only, from 10.1 to 10.15 MHz. The 10.109-10.115 MHz slot, however, was held back to protect existing users. The band was opened at 1900Z on the 28th, with W1AW, K1ZZ, W1XX, and W9JUV among the many taking part in the U.S. 30-meter inaugural.

A Possible Conflict with the new band and also the 18 and 24 MHz bands has surfaced in FCC General Docket 82-625, released mid September. This Notice of Proposed Rule Making would open many segments of the 2-25 MHz HF spectrum, including the three new WARC bands (but no other Amateur frequencies), to various licensees in industrial radio services. Telephone and power companies plus oil, gas, and mineral exploration firms would all be authorized to use these frequencies when it was in the "national interest."

These Proposals Conflict With Other New WARC 79 Assignments as well as with the new Amateur bands, but it's predicted that frequencies conflicting with WARC allocations will be deleted as the NPRM is reviewed. The ARRL did, however, file comments pointing out the conflict prior to the comment closing date of November 5.

A "SPACE DXPEDITION" IS ALMOST CERTAIN FOR NEXT YEAR, when astronaut Owen Garriott, W5LFL, will fly the space shuttle Columbia's ninth mission. After lengthy negotiations, NASA Houston agreed to let him take a specially reworked 2-meter handheld along, to operate when possible with a ground plane in the cargo bay. Only final approval from Washington is still needed for the October, 1983, operation, which would last seven days.

NOVICE EXAMS WOULD BE PREPARED AND GRADED as well as administered by Amateur volunteer examiners under an NPRM put forth by the Commissioners at their October 19 agenda meeting. It's proposed that examiners would make up an exam using the FCC Novice syllabus as a guide, let the applicant answer the questions, and then grade it. If the applicant passes both the written and the CW test, the examiner would note that on the applicant's Form 610, which would then be sent to Gettysburg where a license would be issued.

Some 97% Now Pass The Novice Exam under present procedures, which require the FCC to issue and grade Novice exams, so little compromise of standards is anticipated. In addition, the simpler procedures would drop about eight weeks from Novice licensing. Comment due date for PR Docket 82-727 had not been released at press time.

The ARRL Detailed Proposal for the preparation and administration of exams by Amateurs was delivered to the FCC on October 22. It should be released as an RM shortly.

Amateur Logbook Requirements Would Be Entirely Eliminated by another NPRM agreed to at that same agenda meeting. In this proposal the few remaining operating log requirements, such as noting changes in control operator, would be deleted, though certain station records would still need to be maintained. Comment due date for PR Docket 82-726 had not been released at press time.

SACRAMENTO AMATEURS MUST GET PERMISSION from a local pay TV Company before acquiring microwave equipment, according to a preliminary injunction issued by a superior court judge. He issued the order after hearing a suit from California Satellite Systems, Inc., against a local Amateur dealer who was also selling down-converters and antennas for the 2150 MHz pay TV band. He made the unusual ruling to "protect" the pay TV company, since they do not encode their signals and Amateur 2300-MHz equipment could be used to intercept the movie channel signals.

"AUTOMATIC CONTROL" OF AMATEUR RADIO BEACONS was authorized by the Commissioners on October 21. This means that operators of U.S. Amateur beacons will no longer have to shut down when they are unavailable to perform control operator functions.

CW Credit For Any Class Amateur License was also granted to holders of any class commercial CW ticket at the same meeting.

BURBANK CITY OFFICIALS ARE IN DEFAULT under federal court rules for having failed to respond to the complaint filed against them to test their severe antenna restrictions (see Observation and Opinion, August, 1982, Ham Radio, and recent Presstops). The judge hearing the case has set November 4 for a status report by the parties. Attorney W9MU, representing Burbank's Amateurs, intends filing a motion for class certification and preliminary injunction prior to the November 4 court date to keep pressure on Burbank officials.

FCC'S POWER MEASUREMENT NPRM, PR Docket 82-624, proposes changing power limits for all classes except Novices to 1500 watts PEP output. Novices would be limited to a 200-watt PEP output. Due date for comments is February 15, 1983; reply comments are due by March 1.

SONIC CABLE TV WAS FINED $6,000 by the FCC for 2-meter interference following a two-year battle by WB6GVO. One third of the fine was for failing to correct the cable channel E problem after citation by an FCC engineer, while the remaining $4,000 was imposed for the California company's on-going illegal interference to Amateur operations on 2 meters!

low cost linear design and construction

Practical design techniques using common power tubes and parts provide 10-40 meter kilowatt amplifier

Constructing a linear amplifier is one way an Amateur can save money. It's not so much that commercial amplifiers are overpriced for the components they contain, but because of OEM pricing, components bought singly may add up to more than the cost of an assembled unit. Home construction allows you to take advantage of a readily available supply of parts (well-stocked junk pile) that can be used or traded for other items.

When constructing your own amplifier, it's usually not possible to exactly duplicate a published design. Modifications are often required to accommodate differences in components. For this reason, a specific design, and more importantly, the steps used to arrive at it, are presented. By providing sufficient data, minor and even major deviations from the specific design can be made while still obtaining good performance.

A review of amplifier design information, such as found in Bill Orr's *Radio Handbook*, in addition to this design data, is helpful prior to starting the project. Other good source material may be found in the *ARRL Handbook* and articles by W6SAI.

tubes

Tubes, and their availability, greatly influence the design approach to be taken. Good sources for low cost tubes are:

1. Surplus, often WW-II
2. Pull-outs from stations on a maintenance schedule
3. TV sweep tubes

A strong recommendation is in order: get the tubes you want to use *before* you start and get at least twice as many as you need, preferably two complete sets of spares. This will save you much trouble later, and possibly much expense (such as buying a low-production tube or making a design change). Test the tubes first, if at all possible, in a friend's rig or by

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table 1. Low-cost tubes for linears.

tube type	E_p, volts	I_p, mA, max.	rated/class C maximum dissipation	notes
6DQ5	800	250	24/100	1
6JE6	800	242	30/100	1
811	1200-1700	160	50/65	2,4
812	1200-1700	160	50/65	2,4
813	2000-2500	250	100/125	2,4
4-125	2000-3000	260	125	3
572B	2750	275	160	3
810	2500	300	125/175	2
4-250	4000	345	250	3
250TH	2000-3000	350	250	3
304TH	2000-3000	900	300	3
4-400	4000	317	400	3

Notes:
1. Average/peak ratio
2. CCS/ICAS ratio
3. Rated dissipation (ratings nomenclature depends on reference used)
4. A number of these tubes are no longer manufactured. Obtain spares prior to starting the design.

using a pair of transformers, one with the proper filament voltage, and a second at 300-700 volts. Test the tube as a diode with a series resistor to give rated current. This test lets you separate out most bad tubes.

Some of the common tubes to look for are listed in **table 1**. Though possibly considered old-fashioned, out of style and even obsolete, they are inexpensive and perfectly usable. If you have a set, with spares, or can find a set, don't be afraid to use them. This includes out-of-date or unusual tubes such as the 810 or the 715. There are some design considerations to look out for, however. These will be covered later.

TV sweep tubes have two ratings, one for average loads and another for peak loads, such as the flyback pulse in a sweep circuit. Average peak and duty cycle terms are important in the operation of any tube, and consequently are important design factors.

In amplifiers used in fm or teleprinter service a constant signal is present at all times, that is, the duty-cycle is 100 percent. With CW, the carrier is keyed on and off with a resulting duty cycle of approximately fifty percent. With SSB voice, the average energy is far below the peak, normally 10-16 dB down. This results in a duty cycle of ten percent or less. Use of clippers and other speech processors can raise SSB signal duty cycles to fifty percent or more. However, thirty to forty percent is probably nearly optimum. Low average power requirements of SSB service is the reason why modern linears can be made so small and why separate ratings are required for SSB and CW operation.

It makes quite a difference in component size if the rig is to be used for SSB only, or if it must also handle FSK teleprinter. This is one of your major design choices. If you are primarily interested in one mode, it's best to design for it and accept the performance you get with other modes.

In my case, eight 4-125s and four 813s were available. A review of some of the local ham stock showed more 813s available. Though nearly equivalent, the greater ruggedness of the 813 plate and the more severe cooling design requirements of the 4-125s tilted the choice toward the 813s.

The next factor considered is the design for input power level. I have never used a linear except on SSB. There didn't seem to be much reason for a linear unless it was well above the output of a normal rig (provided by most modern transceivers). This indicated a 2 kW PEP design. Experience indicates that a moderate amount of speech processing is best, with heavy processing only needed during pile-ups. Consequently, a normal duty-cycle of twenty to thirty percent seemed appropriate, with a capability of increasing to fifty percent. This allows for pile-up processing and CW if ever needed. It's preferable to design for peak outputs of at least twenty percent greater than normally used. A design capable of thirty percent duty-cycle at 2200 watts input, but with normal operation set for about 1800-1900 watts, would satisfy this requirement.

Amplifier efficiency for SSB operation is normally fifty percent at an average input level, versus sixty-five percent for CW. At an average input of 600

watts, approximately 300 watts of dissipation is indicated. This requires three 813s, with some safety factor, or two 813s with some overloading or operation at reduced power levels.

However, average dissipation is not the whole story. Peak operation must also be considered. At 2200 volts a 2200 watt capability means one ampere of plate current. This is twice the rating of a pair of 813s, and thirty-three percent more than three would supply.

One solution is to use four 813s. However, there is another approach. To see this, look at the tube ratings in table 2. Note that the major differences between continuous commercial and Amateur service is a lower plate dissipation, plate voltage, and current. The instantaneous plate voltage is allowed to go to 3200 volts and the peak plate current to 300 mA in the CCS a-m service, and even higher, to 4000 volts and 400 mA in the Amateur a-m service. Continuously-applied voltage is allowed to go to 2500 volts in the Amateur af amplifier service. However, in all cases, the plate dissipation must not exceed the CCS and Amateur limits of 100 and 125 watts, respectively.

The point is, we can choose a combination of operating conditions to suit the service we plan, within reasonable limits, as long as we do not exceed the rated plate dissipation. For example, for the 813:

For several continuous hours of teleprinter

$$E_p = 2{,}000,\ i_p = 180\,mA,\ P_{out} = 275\ watts$$

For typical CW

$$E_p = 2250,\ i_p = 220\,mA,\ P_{out} = 375\ watts$$

For non-processed SSB, at peak input

$$E_p = 2500,\ i_p = 300\,mA,\ P_{out} = 450\ watts$$

For SSB, with compression, at peak input

$$E_p = 2250,\ i_p = 220\,mA,\ P_{out} = 375\ watts$$

We could even raise the plate voltage for SSB to 1.5 times the normal commercial voltage, or approximately 2700-3000 volts. This isn't really good for the 813, since the internal construction leakage path is short. Other tubes, such as the 250TH or even some sweep tubes, have longer leakage paths but they already have maximum specified high voltage ratings. (Higher voltage operation makes it easier to drive the tube to peak output.)

We can now make another selection, the amplifier input, and the number of tubes required. Let's assume that a full "gallon" was the goal. For continuous teleprinter use, three 813s are required. CW could be handled with two 813s, and SSB operation, with or without processing, requires three tubes. (The allowable PEP input decreases from 2 kW with no compression, since the average input must be kept under 1000 watts, as indicated by a meter.)

Other types require an even larger number of tubes. The extreme would be the sweep tubes, where eight or even ten would be required to achieve 2 kW PEP. As we will see, the design for this is special, but by no means impossible.

Incidentally, during the design stage we find there is some difference in circuit parameters for the CW, teleprinter, and SSB conditions. Simple designs represent performance compromises for some services. An alternative is to change the tube voltage-current operating point to suit the circuit, as done in the big Henry amplifiers.

I chose three 813s, with plate voltages between 2250 and 2500. Since SSB was the primary mode of operation, no special provision for CW or teleprinter seemed necessary. However, each designer should decide what modes are important and how much of a performance trade-off he's willing to accept.

power supply, part 1

At this point it's a good idea to consider some of the other large components — those in the power supply. The plate transformer is the key to this, and you may find some trading or surplus purchasing necessary (have you priced new kW supply transformers lately?).

Though large-capacity high voltage electrolytic capacitors aren't as common as they were a few years ago, they are still available. Because of size and weight problems, choke input and half-wave filtering are not attractive. The remaining choices are full wave, bridge and full-wave doubler circuits. For these, and capacity input, the transformer should have an RMS high voltage rating of about the plate voltage times 1.12, 0.56, and 0.3, for the three types respectively. DC voltages of 2200-2500 equate to 2500-2800 volts (CT) for the full wave, 1250-1400 volts for the bridge, and about 675-750 volts for the doubler.

Transformer power ratings are 1 kW continuous for teleprinter and CW, about 2 kW intermittent for heavily-processed SSB, but as low as 300-500 watts for SSB with no processing. This amounts to perhaps 60, 40, and 20 pounds, respectively — quite a difference due to duty cycle.

When you get a transformer with the required voltage and rating, you are ready to proceed with the design. My transformer turned out to be 925 volts each side of center tap, at 500 mA dc, ample for 300 watts continuous or a full gallon at a thirty percent duty

table 2. Typical operating characteristics.

tube type	811	572B	813	4-125
E_{FIL}	6.3	7.5	10	5
I_{FIL}	4	4	5	6.5
E_B	1700	2400	2500	2500
I_p rest	30	20	30	15
$I_p$max	160	250	200	110
I_g max	28	45	50	55
R_K	320	215	270	340
R_L	5200	4500	7000	13500
drive power	15	30	11	16
input power	270	600	500	275
output power	175	350	350	190
average dissipation	65	160	150	85
		for 2 kW PEP input		
no. tubes	4	4	3	4
Z plate	1300	1150	1750	3350
C tank-in (note 1)	300 pF	450 pF	225 pF	128 pF
L tank (note 1)	7.9 μH	5.4 μH	10.1 μH	17 μH
C tank-out (note 1)	1420 pF	1850 pF	1100 pF	50 pF

Notes:
1. Component values are given for 3.5 MHz
2. Design data is for 2 kW PEP grounded-grid linear service. Based on *Radio Handbook* data.

cycle. This was chosen over another rated at 725 volts each side of center-tap at 1.3 amperes, simply because of size and weight.

When selecting a transformer, don't forget to look at combination possibilities. If the transformers are rated for high altitude operation or show an adequate test voltage, it's safe to put two secondaries in series. Two identical secondaries in parallel are also okay. Don't forget the possibility of a low voltage transformer connected to buck or boost line voltage to allow use of the odd-voltage transformers you sometimes find, for example, with 170-volt or 265-volt primaries.

While you are searching for a transformer, look for filter capacitors. You will need a minimum (capacitance) of:

For full-wave or bridge rectifiers:

$$C = \frac{50,000\, I_{max}}{E_p} \text{ microfarads}$$

For a voltage doubler:

$$C = \frac{150,000\, I_{max}}{E_p} \text{ microfarads}$$

For a 2200-volt bridge-rectifier type of supply, capable of one ampere, this amounts to 22 μF, or to 132 μF at 450 volts working with six in series, and 175 μF at 350 volts working with eight in series. These include an allowance for voltage surges. If possible, use even larger capacitors.

the plate circuit

With the basic tube operating conditions established, final design can start. As is common today, a single-ended design with tubes in parallel is assumed, since multi-band operation is much simpler.

The plate circuit looks like a generator, with an impedance of

$$R_p = \frac{E_p}{k \times i_{p\,design}} \text{ ohms}$$

where k equals 1.57 for a linear amplifier and 2 for a Class C amplifier. For an amplifier designed with reserve power capability, for example, one ampere at 2200 volts in linear operation, the plate resistance is 1400 ohms. For Class C operation it would be 1100 ohms. (Alternately, we could change the operating conditions of the tube to give the same impedance, say to 2500 volts at 850 mA.) The other alternative is to operate Class B for CW as well as SSB. This was the approach taken in this design.

A pi-matching circuit is normally used to transform this impedance to 50 ohms, needed for coax feed. The input capacitor reactance is:

$$X_c = \frac{R_p}{Q} \text{ ohms}$$

where a Q of ten is considered optimum. For the 813 design, this amounts to a reactance of 140 ohms, corresponding to an input capacitance of about 35 pF at 30 MHz, and to 340 pF at 3.5 MHz.

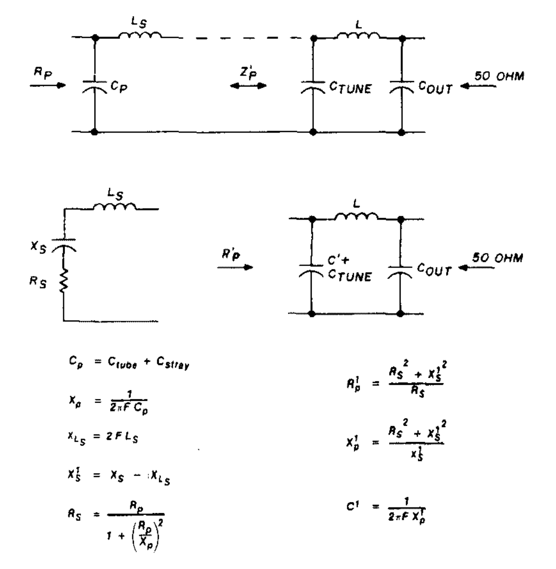


fig. 1. Principle of L-pi-network design for high tube capacity systems. The equations are for parallel-series, series-parallel transformations.

Here we run into a small problem. The plate circuit capacity of a single 813 is 14 pF, so we are faced with a capacity of 42 pF for the tubes alone. Adding 5 pF for strays, and 10 pF for tuning-capacitor minimum gives a pi-input capacity of 57 pF, too much for a Q of ten. The problem would be even worse if sweep tubes are used, eight in parallel giving as much as 160-pF plate capacity, with a total circuit capacitance of 180 pF. (Of course, the plate circuit resistance goes down also, to about 320 ohms, so a Q of 10 would allow as much as 150 pF.)

One way of solving this problem is to accept a higher Q on 10 and perhaps 15 meters. Using the previous values, this equates to a Q of 12, normally considered somewhat high, but acceptable.

Another way to handle this is to abandon the pi-network circuit. A push-pull tank could solve the problem. Past editions of the *ARRL Handbook* show a tapped-coil sweep-tube design, fine for a single band, but a nuisance for multiple band operation. Or, we could simply regard the output as a low impedance capacity-shunted source, as is done in transistor designs.

There is another approach which doesn't seem to have been described before. As a matter of fact, it should be considered in any matching design network above 14 MHz. The approach regards the output circuit as two networks in series. One of these is the normal pi-output circuit, and the second is the L network composed of tube and associated stray capacitance, plus the inductance of the lead from the tube or tubes to the pi-network. Its equivalent circuit with the given design parameters is shown in **fig. 1**.

To see the importance of the technique use the given values: 1400 ohm plate impedance and $42 + 5 = 47\ pF$ of tube and stray capacitance. Assume that the lead from the tank circuit to the tubes is only four inches long, with a diameter of one-eighth inch, giving an inductance of about 0.05 μH, and a reactance of about ten ohms at 30 MHz. Performing the parallel-to-series conversion, reducing the capacitive reactance by this amount and converting back again, gives an equivalent driving point impedance of 1170 ohms, and a shunt reactance of 109 ohms, or 50 pF. With a tank circuit Q of 10, the value of X_{C1} becomes 117 ohms, or 55 pF. A capacitor of 5 pF minimum capacity can be used and still obtain a pi-section Q of 10.

If the allowable capacity is still less than the tube and stray capacitance, the length of the plate lead can be further increased. However, the equivalent drive resistance will also decrease. Several more repetitions may be needed to obtain a workable combination.

Once the values have been obtained for the highest band, repeat the calculation for the next few lower bands. When the equivalent resistance approaches the tube resistance, use this for the lower bands, while maintaining a Q of 10. The values of the pi-network elements are then calculated using the formulas in **fig. 2**. Don't forget to use the equivalent impedance for R_1 at the higher bands.

What type of inductance should be used? Roller coils allow one to closely adjust circuit parameters for maximum efficiency, but they are expensive. Tap switching is perfectly acceptable, and there are many old tuner switches available that provide rugged low-resistance design. Looking ahead with eight bands between 3 and 30 MHz, the number of taps may be excessive. You may want to consider having one linear for 1.7-7.5 MHz, and another for 10-30 MHz.

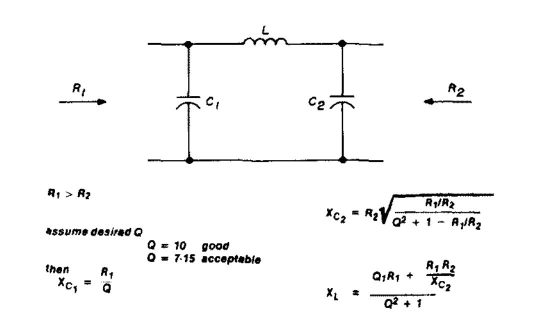


fig. 2. Circuit relations for pi-networks. If Qs below ten are necessary, harmonic rejection is low. High-Q circuits increase operating loss.

This was my choice. It certainly makes design a lot easier.

the input circuit

The driving-point impedance, Z_K, of a grounded-grid amplifier is

$$Z_K \approx \frac{e_{g\,max}}{i_{1\,max} + 1.5\,I_C} \approx 0.6\,i_p$$

where e_g = *rms grid drive voltage*
I_C = *cathode current*
i_{max} = *fundamental current*

For most combinations of tubes, this will probably be between 50 and 150 ohms.

The input circuit must be reasonably well-matched to the driving amplifier. It must also provide a load to the amplifier when the tube is cut off (Class C), or nearly so (Class B).

While the drive power used in grounded-grid operation is much greater than for grounded-cathode service, provisions must be made to prevent an overdrive condition from occurring. (Modern transceivers have more than sufficient output power). An automatic overdrive protection circuit is one possibility.

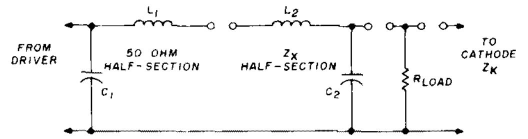
The usual way of preventing overdrive is to use a low Q tuned circuit in the cathode, say a Q of 2, plus ALC feedback to set the level. This is perfectly acceptable if the ALC is not forced to work too hard. However, the added coil switching is a nuisance.

An alternate method that doesn't use switching is shown in **fig. 3**. A lowpass filter, used in the drive circuit, provides an impedance transformation from 50 ohms to the tubes' input resistance. The filter output drives the tubes' cathodes and a resistor bank. The latter provides a load to the driver during the entire input cycle, and dissipates part of the driver's excess power.

Circuit losses and a varying driver load complicate the calculation of the required resistance. As an approximation for designs where between thirty to fifty percent of the rated driver output is required, a resistance of five times the cathode impedance has worked well. Basically, start with a higher resistance and monitor the drive level. If it is still excessive reduce the loading resistance until the exciter's maximum output just drives the amplifier throughout its linear range.

High power-rating resistors are not needed. For example, if the total drive is 50 watts, the resistors dissipate only 10-12 watts of it (using the above rule of thumb). A bank of six two-watt resistors will do.

Even though 813s have an isolated cathode, a filament choke is a good idea. For a kW amplifier, the choke core can be a 6-8 inch (150-200 mm) long, ½-inch (12.7 mm) diameter ferrite rod. If the amplifier is



$m = \frac{Z_X}{50}$

For 1 ohm, 1 radian

C_1 = 1 farad

$L = L_1 + L_2 = 1 + m$ Henries

$C_2 = 1/m$ farads

For a cutoff of 45 MHz

$C_1 = \frac{1}{50} \times \frac{1}{2\pi \times 45 \times 10^6} = 70\ pF$

$C_2 = C_1/m$

$L = (1 + m) \cdot 50 \cdot \frac{1}{2\pi \times 10^6} = 0.177\,(1 + m)\,\mu H$

fig. 3. Circuit relations for impedance matching low-pass filters. This is used instead of a tuned input in order to simplify the design.

to cover only the higher bands, 10 through 40, the winding can be trifilar, with two elements the filament conductors, the third a nylon cord, or other non-moisture absorbing spacer with the same wire diameter. For low frequency use, the filament leads can be bifilar wound. Number 12 wire is ample for three 813s, but be sure to estimate the voltage drop and allow for it when selecting a filament transformer. Low filament voltage causes problems with linearity and tube life.

One nice feature of the 813 is that it doesn't require bias in grounded-grid operation. If the operating mode requires bias, it can best be obtained by using a Zener diode. Shunt it with a resistor that will draw approximately ten percent of the expected grid plus plate current. This helps prevent instability. If a power Zener is not available, the circuit of **fig. 4** can be used.

power supply, part 2

Let's return to the power supply, keeping it simple. Our basic requirements are:

1. Apply only filament power for an adequate warm-up period.
2. Initially apply power to the plate circuit at a low level, to hold capacitor charge current down.
3. Apply full power to the plate circuit.
4. Remove plate and filament power simultaneously, or plate before filament.

We also want adequate protection for ourselves and the equipment. We can accomplish these functions manually, semi-automatically, or in a fully automatic mode. However, cost increases as the system becomes more automatic (complex).

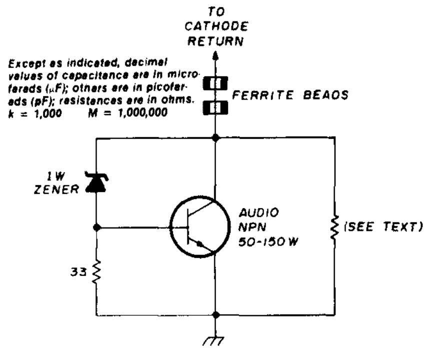


fig. 4. High power Zener diode substitution circuit. The drop across the circuit will be slightly greater than the voltage across the low power Zener.

A simple way of achieving partially protected manual operation is to use a progressively-operated switch for the transformer primary, as shown in **fig. 5A**. The first position turns on the filaments. After a short delay, the switch is placed in the second position, feeding power to the plate transformer through a dropping resistor. After an additional (short) delay full power is achieved by placing the switch in the operate position. This can be further modified by including one more intermediate voltage switch position.

For 120-volt operation, a single section switch can be used, as shown. Old TUs and Navy surplus are a good source of multi-position or rotary type switches. For 220-volt operation, both sides of the line should be switched for safety.

A simple semi-automatic version is shown in **fig. 5B**. Filament power goes on when the master switch is on. This enables a relay circuit, picked up when the transmitter is keyed. It applies power to the plate circuit and a series resistor holds this low until the capacitors charge up. This is controlled by another relay across the transformer primary, which activates when the charging current drops, shorting the series resistor. The first relay can be the antenna changeover relay.

This circuit is easily made automatic by activating the first relay from a time delay device, such as a fluorescent lamp starter. The relay removes power from the delay device when it activates. It should be separate from the antenna relay.

metering, antenna switching and ALC

Though simple metering is desirable, it must be remembered that good metering can help improve performance and extend tube life. Also, the FCC requires input power-level monitoring if it exceeds 900 watts (or 1800 watts PEP).

If automatic drive limiting is used and set at the 1800 watt level, safe, legal operation with simplified metering is possible. **Figs. 6A** and **6B** show two possibilities, the first measuring cathode current only, the second measuring grid and plate current. An external output wattmeter should also be used.

A plate voltage indication is also useful, and can serve as an ON indicator. An inexpensive type uses a neon bulb, connected across the bottom capacitor of the filter bank. The indicator warns of unusual conditions, including shorted or open capacitors, and excessive drain. Note that two resistors are shown across each filter capacitor. One serves as a bleeder and voltage-equalizing resistor and is normally wirewound. The second is a composition resistor, of 1 watt rated dissipation. It is a safety device that ensures filter discharge in case the wirewound resistor opens up. Good design practice is to choose the bleed resistors so that the sum of their drain plus the

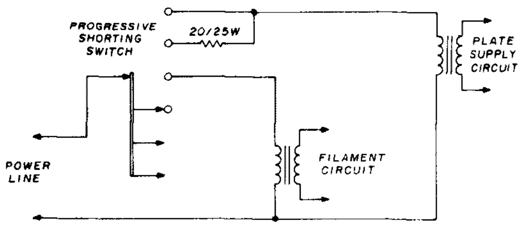


fig. 5A. Manual power-supply switching using a progressive shorting switch. The switch should be left ten to twenty seconds in each position. This provides filament preheat and in-rush surge protection.

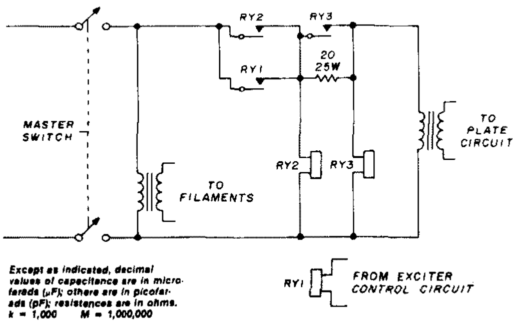


fig. 5B. Semi-automatic power-supply switching. Filament power is applied when the master switch is on. Plate power is brought up in two steps when the transmitter is keyed. This is after a ten to twenty second initial delay.

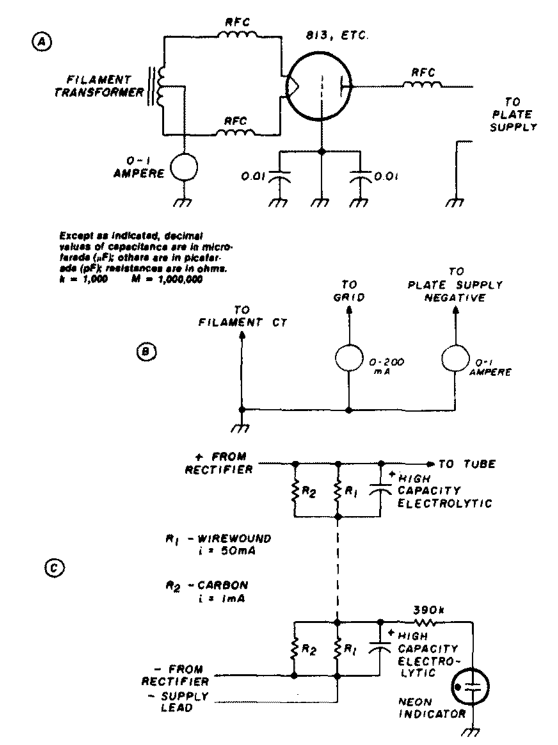


fig. 6. Metering circuits. At (A), a single meter is used to read total cathode current. At (B), two meters read plate and grid currents. At (C), a neon tube indicates plate voltage, and serves as a safety indicator.

idling current of the tubes is about ten percent of the design peak current.

I prefer to use a multiple pole relay in the antenna change-over circuit, wired as shown in **fig. 7A**. This provides protection for a receiver-transmitter combination, or a separate receiver used with a transceiver. (A 6-10 dB pad can be connected in this separate circuit to reduce signal loss in the *main* path due to paralleling mismatch.) Separate contacts on the relay can be used for power control, or for control of external devices.

While the trick of loading the input circuit can eliminate the need for an automatic level control, it's still a good idea to provide this. For one thing, you may want to use a different transmitter than designed for, and the back-up protection is beneficial.

The simplest approach to ALC is to use an rf level measurement technique to develop a threshold voltage. An ALC circuit is shown in **fig. 7B**. Assuming the grid loading has been adjusted, the ALC threshold control is set to give a barely discernible deflection on a VTVM at maximum design output. It can then serve as a backup for improper load.

TVI Prevention

Prevention of TVI is a design goal for any transmitter. Most of the basic steps can be handled fairly late in the design stage, but there are a few that must be initially considered. One of these is the nature and extent of needed output coax filtering. Lower circuit Q increases the need for filtering. For example, with a Q of 10, a two-section, lowpass filter will probably be sufficient though a three-section filter is better. For higher harmonic rejection, it's a good idea to install a form of suck-out trap. On a low-frequency transmitter, it can be placed across the plate circuit. However, the added capacitance is undesirable on the higher-frequency bands. For these, a trap at the point of attachment of the output coax to the pi-section loading capacitor is indicated. The trap can be a high-pass filter, with a small bank of load resistors to dissipate any harmonic energy present. A design using a 50-ohm load seems to work well. The cutoff frequency should be between the highest operating frequency and the TV i-f frequency of 45 MHz.

The filters will probably not be effective if the self-resonant frequencies of the grid and plate circuits occur at the same frequency and near any of the TV bands. Unfortunately, there is a version of Murphy's

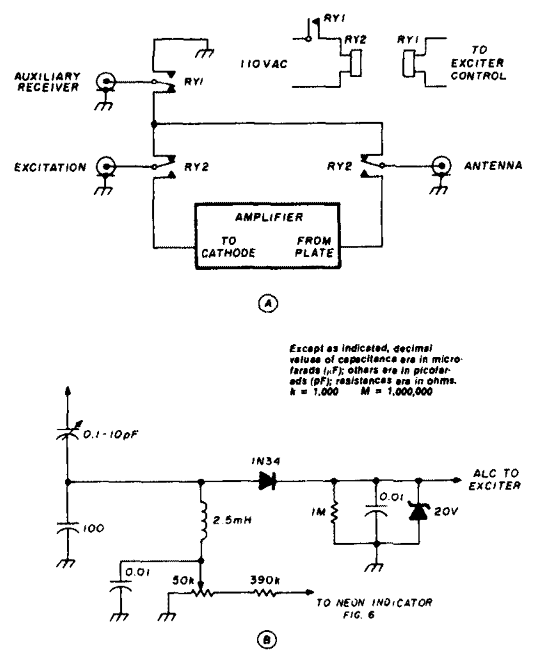


fig. 7. (A). Antenna changeover relays provide a spare contact to feed an auxiliary receiver and ground it during transmit. (B). An ALC circuit provides an adjustable threshold voltage from the plate tank circuit.

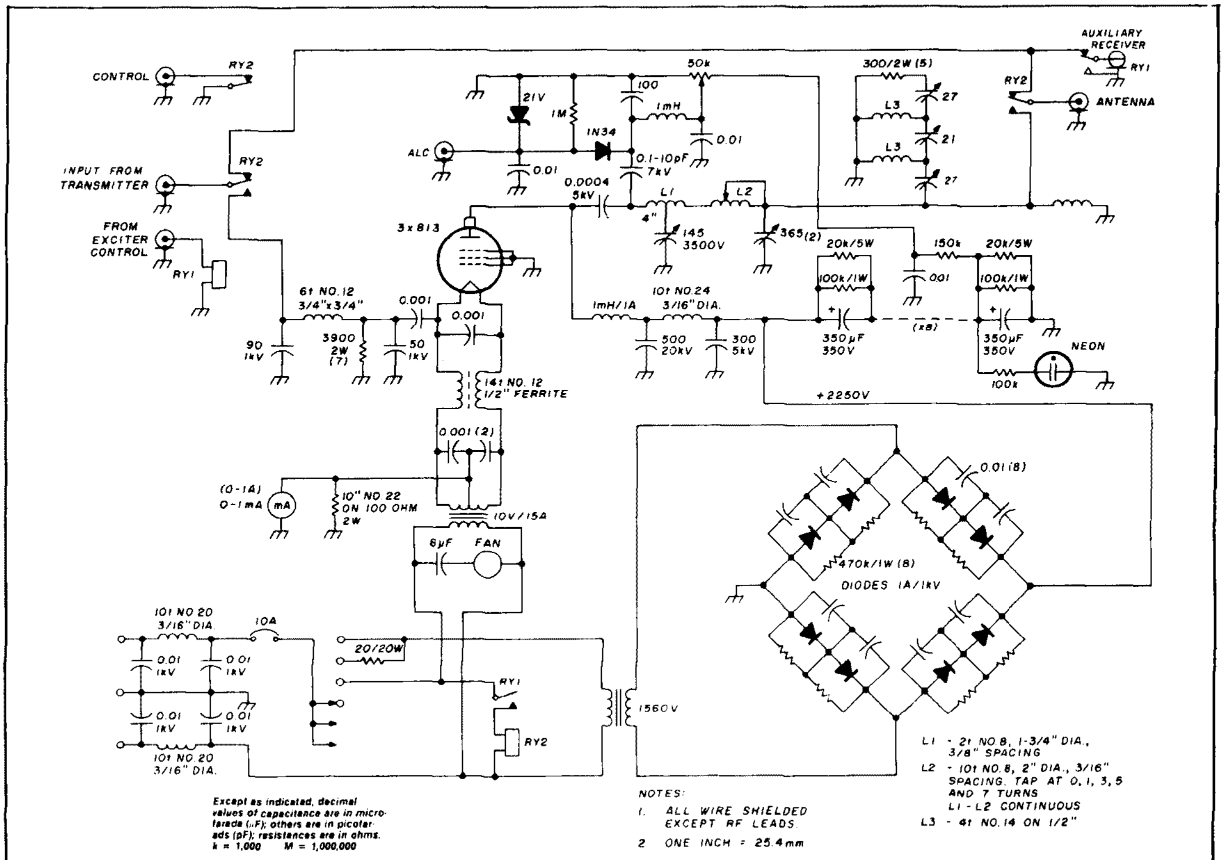


fig. 8. Complete circuit of a full-gallon linear using three 813 tubes. Note the harmonic trap at the output. A series filter is also externally used.

law which applies here. Try to design the circuit components and layout to give high self-resonant and well-separated frequencies. The filter-drive grid circuit helps, but the plate load modification using series inductance can be a handicap, forcing a high Q tank for TVI prevention. Measure the resonant frequencies as the construction progresses, and modify the design if necessary.

In addition, all the standard TVI prevention practices should be followed. Each lead should have an LC filter where it enters the shield enclosure. Internally, use shielded (high capacity) leads. Dial shaft holes should be small, and a metal shaft should have a ground spring contact on the inside of the cabinet. It should have this for safety anyway if high voltage is near it. Meters should be metal-cased, with filters at the terminals, or have a piece of screen wire across the face, with the entire meter case inside the formed shield.

Internally, watch the ground current paths. Keep joints out of the path, and don't forget to provide a path for the rf flowing through the tuning capacitor to get back to the tube cathode. If the tube is to be recessed below a chassis, make the mounting holes sufficiently large.

Parasitics, another cause of TVI, are reduced or eliminated by placing suppressors in the plate circuit. Neutralization may be called for in grounded-grid design, and certainly in grounded-cathode circuits. The use of loading to absorb excess driving power greatly reduces the problem, however, and may be a sufficient measure in itself. It might eliminate the need for neutralization. This is easily added by a small tertiary winding on the filament choke, grounded at one end and coupled to the plate from the other end through a variable neutralizing capacitor.

mechanical construction

Kilowatt amplifiers, especially single package types, are large. Don't try to shoehorn everything in. Try to leave at least two-inch clearance for all rf components. The power supply isn't critical, but *don't*

forget cooling. This is vital for the tubes. Cool tubes are less likely to fail prematurely.

Symmetry in the tube area of a multiple tube design is recommended. Keep lead lengths the same. These techniques help equalize the load distribution. Elsewhere, symmetry is not necessary. Don't force the layout to give a symmetrical front panel.

For homebrew construction, a dual-chassis layout seems to work well. A horizontal section contains the tubes and rf components, and a vertical section the power supply. Input and control elements are under the horizontal section. Front and rear panels, plus a U-shaped top and end and a flat bottom part, complete the mechanical elements. Use angles along the top and sides of the panels.

Perforated aluminum is fine for the top, ends, and bottom of this design, but a lot of screws will be necessary to make the joints rf-tight. A better way of fastening is to use 1/8-inch aluminum strap along all edges, clamping the thin perforated metal between this and angle sections, with screws every six inches or so. Front panel appearance is improved if the strap projects a 1/4-inch (6.4 mm) over the shield edge.

A compact linear layout is possible if the power supply is built separately. The two-chassis design works well with the tubes mounted horizontally. Four 811s or even 872s can be placed in a cabinet measuring 5-1/2 × 10 × 12 inches (140 × 254 × 305 mm). Rf components will be a little crowded, though, and a good cooling fan is a must.

Home-built designs don't need to be sloppy in appearance. Be careful to avoid dents and scratches, and paint the completed unit, either to match other gear or to contrast with it. (Don't paint mating-shield surfaces.) Use appropriate size stick-on or transfer lettering to label controls and the unit itself.

A special note: use honest-to-goodness dials, with engraved marks or a digital readout that can be preset to one degree or better. Keep a log of readings for each band. If manufacturers were more careful with their dial designs, we would have far less tune-up QRM on the bands.

putting it all together

Fig. 8 is the schematic of the linear used at W4MB for several years. These basic design goals were considered:

1. Legal limit with good linearity
2. Drive from two 6146s
3. 10-40 meter operation, with new band operation considered
4. Separate antenna tuning
5. Separate lowpass filter

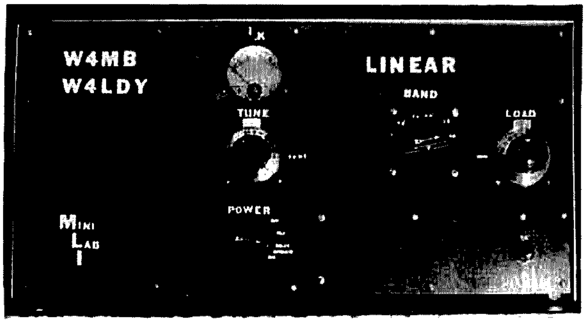


fig. 9. General view of the amplifier of fig. 8. Note the TU-type bar knobs, and the vernier dials with calibrated scales for tune and load (makes band changing easier). Note the screen-wire shield over the meter.

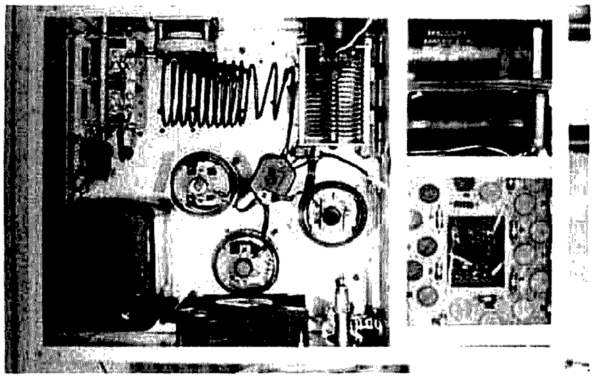


fig. 10. Top view of the amplifier. The rf section is at the top, the plate supply on right, and the filament transformer at the lower left. The harmonic trap is just above the filament transformer. The tank coil is constructed from a continuous length of heavy wire. The ALC circuit is at the bottom center.

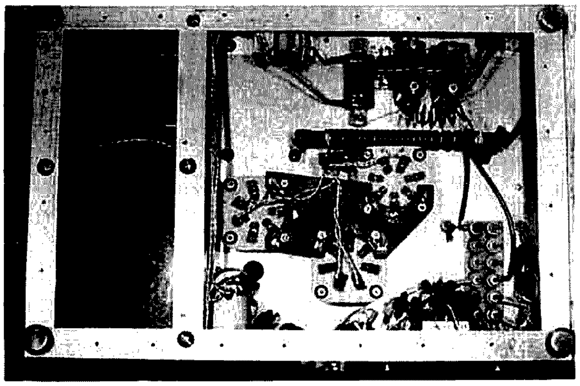


fig. 11. Bottom view of the amplifier. The copper plate in the center grounds all grids to chassis using metal standoffs. The grid filter and loading resistors are at the upper right. The coil is adjusted by spreading or squeezing turns to set the cut-off frequency above the 10-meter band.

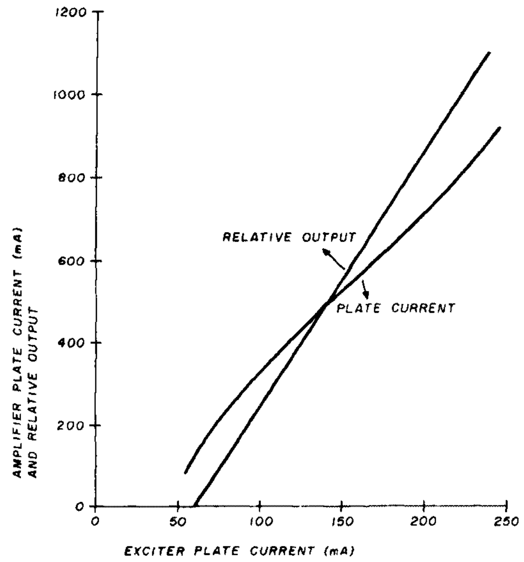


fig. 12. Linear performance of the W4MB-W4LDY three (tube) 813 amplifier is shown. Actual flat-topping starts at about 1250 mA of plate current, well above the legal limit. This illustrates how an extended linearity design is an important factor in providing a clean signal.

6. Use tubes and components on hand
7. Simple switching

Fig. 9 provides an overall view of the transmitter, fig. **10** the inside top view, and fig. **11** the bottom view. Note the use of a copper plate to connect the various drive grounds together, and the arrangement for making filament lengths the same. Plate leads are also the same length. The layout lead length brings the effective *Q* of the tank circuit to about 10.5 on 10 meters.

A graph of amplifier linearity is shown in fig. **12**. More output is possible, but the combination of input loading and ALC limits the maximum input to 1800 watts PEP (note that this is above the legal limit if appreciable speech processing is used).

As seen in the photographs, there are no parasitic suppressors in the plate circuit in this design. No instability was noticed during testing. There have been one or two reports of a wide signal, so possibly some instability can arise as a result of load variation or mis-tuning. All solicited critical signal checks have agreed with the data and with unsolicited reports. This amplifier, as intended, produces a clean signal, and, because of its simplicity, is also a pleasure to operate.

ham radio

an improved TouchTone* decoder

ITT's device provides simple, reliable crystal-controlled decoding of DTMF signals

Several years ago, ITT (International Telephone and Telegraph) introduced a single integrated circuit capable of decoding TouchTone* signals. Using this device, we can construct a decoder system suitable for use in remote control applications with a microprocessor.

Nearly all remote control of Amateur Radio equipment, be it of a repeater, an autopatch, or a remotely controlled station, is at least in part accomplished by the use of TouchTones, also known as DTMF (Dual-Tone, Multiple-Frequency) signals. Since most modern Amateur VHF and UHF equipment now on the market is available with DTMF-encoded keyboards that provide either twelve or sixteen combinations, the transmitter end of a control link is readily available.

At the receiving end, some means must be provided to detect and decode the incoming DTMF signals (as the name implies, each signal consists of a pair of tones transmitted simultaneously). In the case of a twelve-key pad, one of a set of three tones is combined with one of a set of four tones, to provide twelve different codes. For a sixteen-key encoder, eight tones total are needed, as shown in **fig. 1**. The decoder must detect these tones and provide some indication that a valid DTMF code has been received); at the same time, the decoder must not be spoofed by the randomly occurring tones in speech sent over the same channel.

*TouchTone is a trademark of the Bell Telephone Company.

prior technology

In the past, Amateurs have often used decoder circuits consisting of a detector tuned for each of the seven or eight tones. The detectors are usually either resonant reed filters, or more recently, monolithic tone-decoder PLL (phase-locked loop) integrated circuits, usually type 567.

My own experience is with this type of decoder system. Typically, they consist of seven 567 ICs, one for each frequency, a demultiplexer circuit to convert the two-of-seven output to a more useful code, such as one-of-ten, or binary. Such decoders work, but they can be a bit tedious to align initially, as each PLL must be individually adjusted. Furthermore, since the accuracy of each PLL detector depends on its RC network, they can drift with temperature changes or with time as the frequency-determining components age. These problems are usually depressingly familiar to anyone who has tried to keep a repeater autopatch decoder operating for any length of time.

an integrated decoder

In the last few years, the telecommunications industry, fueled by tremendous growth in the commercial markets, has begun to integrate many previously discrete components into more compact monolithic circuitry, in order to reduce the size and cost of communications equipment. Examples of this process are seen in ICs that replace the hybrid transformer in telephones, in the replacement of bulky analog filters by monolithic active filters and, recently, with the development of integrated DTMF decoder circuits.

One such DTMF decoder IC is ITT's 3201, which can decode all sixteen standard TouchTone signals to provide a four-bit binary output (see **table 1**). It uses an inexpensive 3.57945 MHz TV colorburst crystal as the frequency reference, so that temperature and age drifts are practically eliminated. In addition, it has excellent immunity to false outputs caused by

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	COLUMN 1 1209 Hz	COLUMN 2 1336 Hz	COLUMN 3 1477 Hz	COLUMN 4 1633 Hz
ROW 1 697 Hz	1	2	3	A
ROW 2 770 Hz	4	5	6	B
ROW 3 852 Hz	7	8	9	C
ROW 4 941 Hz	*	0	#	D

fig. 1. Sixteen-key TouchTone pad shows how each key is assigned a discrete pair of tones.

table 1. Code list of the output of ITT's 3201 DTMF decoder IC.

input TouchTone code	outputs binary	decimal equivalent
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
0	1010	10
*	1011	11
#	1100	12
A	1101	13
B	1110	14
C	1111	15
D	0000	0

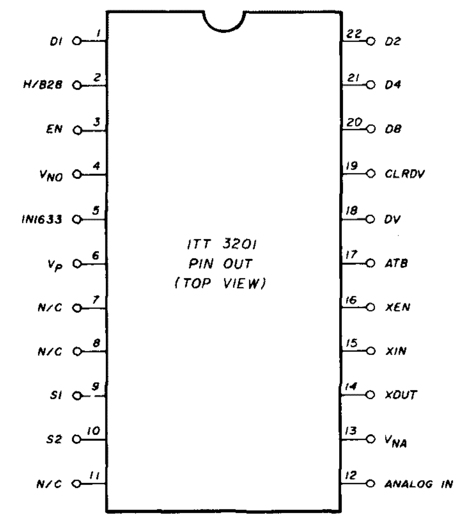

fig. 2. Pin assignments of the 3201 decoder.

speech or noise on its input. In this single IC are all the functions that my old 567-type decoder board failed to duplicate fully with ten ICs.

Fig. 2 shows that the 3201 is a CMOS LSIC (large-scale integrated circuit) housed in a 22-pin DIP. It requires only a single power supply, and draws little current. No front-end filtering is required, nor does the input have to be split into high and low bands, as some other DTMF ICs require. Audio from the receiver is fed directly to the 3201, and is automatically decoded.

The only catch, if there is one, is that the price is still higher than for the 567-type decoder. At the time of writing, the single-piece price for the 3201 is about $43.00, but that price should fall as the production quantity increases. In fact, the price has already fallen quite dramatically since the introductory price of $95.00. (The trend in semiconductors is that they are expensive when introduced, and the price then steadily falls as the volume of use rises; this IC should not be an exception to that industry-wide rule).

My own feeling is that the cost of the device, if a bit high, is more than compensated for by the utter simplicity of its construction and adjustment, and by the long-term benefits of stable, crystal-controlled operation.

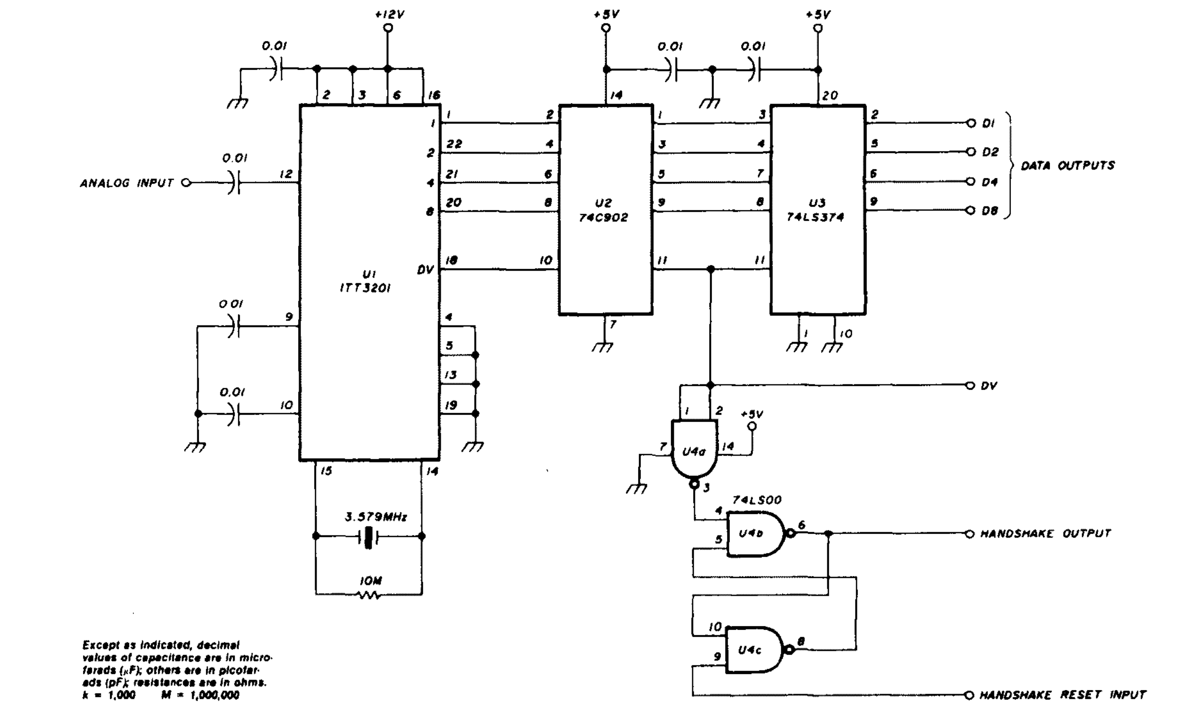

fig. 3. Schematic diagram of a decoder system. This circuit accepts a TouchTone input signal and produces a four-bit TTL-level output.

circuit description

In fig. 3, audio from the receiving system is fed to the high-impedance analog input of the 3201. If the input signal is a valid DTMF tone pair, the 3201 produces an output on the four data lines. During the time a tone is being received and decoded, the DV (Data Valid) output goes to the logic-high state.

The DV line serves as a signal that the four data outputs contain valid data; while DV is high, the data are good, and so the transition of DV from low to high can be used to latch the output of the decoder. The data latch (U3 in the diagram) is needed so that fleeting input signals (which may be as short as 40 milliseconds in length) can be held and read at a later time.

The output of the 3201 is CMOS level, and is not directly compatible with the usual TTL interface circuitry used in most microcomputers. This incompatibility is corrected by U2, the 74C902, a CMOS-to-TTL level converter.

Thus, when a valid DTMF signal is fed to the input of the 3201, properly-decoded output signals appear at the output lines of U2, and the DV output goes high. This transition of DV from low to high is used to clock U3, the 74LS374 octal data latch, which holds the decoded equivalent of the last DTMF signal received.

In order for a microcomputer system to tell the difference between a *newly* received DTMF input and a previously stored word, a handshake circuit has been included. This handshake is set by the DV line, and is reset after the word has been read by the computer. In other words: the output of the handshake latch goes high when the 3201 puts a new word into the data storage latch, and is reset again when the computer reads the output of the data latch. Therefore, if the computer is programmed to first look at the handshake output, it can determine if a new word is waiting to be read.

Since any computer that monitors the decoder can scan the output lines much faster than an operator's finger can press a button on the DTMF encoder keyboard, it is also a good idea to have the computer watch the DV line so it can tell a long input tone, which it has already read, from a newly received tone. The DV line, used in this way, is a form of key debouncing and prevents reading one tone as a series of several digits.

construction and testing

Layout and construction of this circuitry is noncritical. The few discrete components, such as the crystal and the bypass capacitors, can be soldered to the IC socket pins, and the rest of the wiring com-

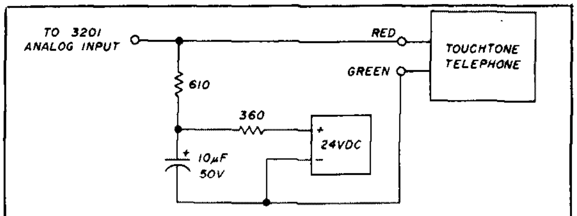

fig. 4. Simple test set uses a TouchTone telephone and a matching network to provide DTMF signals.

pleted with wire-wrap interconnections. (I built my decoder on a small prototype board with an edge connector to which the input and output were wired.)

Once the wiring is completed, and the supply voltages have been checked at the socket pins, the ICs can be installed. Keep in mind that the high-impedance input of the 3201, which is a CMOS device, is sensitive to damage by static electric charges. It is a good idea to keep the 3201 in the protective packaging it comes in until it is to be installed, and then equalize the potential of the circuit and the protective package by touching them together. Remove the 3201 and install it in its socket. Once the IC is installed, the danger of static charge damage is reduced.

There are no adjustable components (this is my kind of circuit!) so the unit should work when power is turned on and a DTMF signal is applied to the analog input. The circuit shown in **fig. 4** is a simple test set that uses a standard TouchTone telephone to determine if the decoder is properly decoding the twelve tones. The telephone is disconnected from the phone lines, and hooked as shown to the network, which provides power for the phone's internal tone generator and matches the normal line impedance of 600 ohms.

If the decoder fails to work, check the wiring first. *The DV line at the* 3201s *pin* 18 should rise to nearly + 12 volts when a DTMF signal is applied; if it does, the problems are probably elsewhere than in the 3201's circuitry.

summary

This decoder is a simple, modern alternative to the DTMF decoders of the past. It provides dependable performance, and should make remote-control systems easier to set up.

Except for the 3201, all the components are standard types and widely available. The 3201 can be obtained from the manufacturer at this address: ITT North Microsystems Division, 700 Hillsboro Plaza, Deerfield Beach, Florida 33441; telephone 305-421-8450.

ham radio

a rotary dial and encoder
for digital tuning

A digital controller using multiple dials and microprocessor logic

The shift to digital and microprocessor control of ham gear makes rotary dial encoding more popular. Earnshaw's approach to dial encoding, simplified and improved by Opal, offers a practical method for the Amateur builder.[1,2] Both require discrete components for each dial.

This article describes another method incorporating multiple dials using microprocessor logic.[3] This method reduces the number of components necessary and is suitable for digital controllers having concurrent tasks.

why encode the rotary dial

Switches are inherently digital; they are either on or off. Conventional tuning dials have an infinite number of positions. A digital tuning dial is not infinite; you must select the position closest to a desired setting.

Most 2-meter fm gear uses some form of discrete, digital frequency selection. This is difficult to use on lower bands without channelized frequencies: that rare DXCC contact may be between positions and will never be reached.

If you have a digitally-controlled master oscillator, one tuning solution is to use a potentiometer (pot) with an analog-to-digital converter. This has limits: an inexpensive pot has less than a full turn and an expensive, ten-turn pot can't be spun continuously (nor does it have the range) of conventional tuners.

A better way is to use the continuous, segmented digital rotary dial and an encoder to determine direction and amount of rotation. Each dial position, or state, is used to drive a counter. The counter provides an input to the controlled function. Encoding may be accomplished through discrete circuitry or through a microprocessor program. The position resolution is limited only by the dimensions and construction quality of your encoding design. I resolve two hundred positions per revolution easily. Opal resolved four hundred, with a larger encoder disk and better construction.

the technique

Earlier rotary dial methods provided continuous updating of dial position, or state-change. This system polls four dials in sequence, to determine if any dial status has changed from the previous poll.

I selected a four-dial input because a station can require several. Four uses might be main tuning, bandspread, filter frequency setting and keyer or keyboard speed control. Four inputs also work well with an 8-bit microprocessor.

the basic dial

Fig. 1 shows the progression of logic states from a pair of optical interrupters scanning the marks on a disk. For any given state, movement of the dial disk

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will yield a new state that defines direction of rotation.

Table 1 summarizes all possible state-change combinations, original state to new state. Valid rotation is implied if only one of the optical interrupter inputs changes. Invalid rotation sensing occurs if both interrupters see a change; this change must be ignored. Invalid sensing could occur if the polling speed is too slow, or sensing could indicate the wrong direction if an even number of state changes were missed.

The microprocessor system used in dial sensing performs other tasks as well. Polling speed is subject to trade-offs. To test the speed, I tentatively selected Opal's fifty-mark encoder disk. Some experimentation with a conventional transceiver proved that the dial spins easily at one revolution per second. This became the design rotation-rate goal. Assuming the rotation algorithm senses all state changes: *(1 rev./Sec)* × *(50 marks/rev.)* × *(4 states/mark)* = *200 states/Sec.* All else being equal, polling rate must occur once every five milliseconds.

Everything else is *not* equal, however. First, the dial spin rate is not constant. Sudden starts and stops create faster state changes. Second, interrupters are not ideally spaced; some state changes occur at a lesser angular displacement and the state-change rate can increase.

With these factors in mind, I finally selected a two millisecond polling rate. The encoder still losses a few counts on rapid dial movement, but I've noticed no erroneous counts.

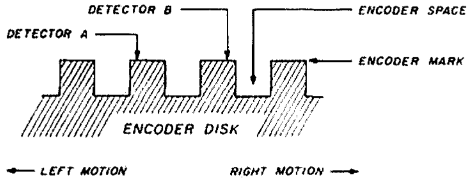
table 1. Matrix diagram (Karnaugh Map) of all possible logic states of one dial's optical interrupter detector. A_0 and B_0 are the previous A and B interrupter states while A_1 and B_1 are the current states. L indicates left motion in *fig. 1*. R is right motion. N/C is no change; dial has not moved. N/A is a not-applicable condition resulting from non-allowed state-change progression of motion in either direction. The logical expression is used by the process subroutine shown in *fig. 4*.

		A_1A_0			
		00	01	11	10
B_1B_0	00	N/C	L	N/C	R
	0	R	N/A	L	N/A
	11	N/C	R	N/C	L
	10	L	N/A	R	N/A

$$L = \bar{A}_1A_0\bar{B}_1\bar{B}_0 + A_1\bar{A}_0B_1B_0 + \bar{A}_1\bar{A}_0B_1\bar{B}_0 + A_1A_0\bar{B}_1B_0$$
$$R = \bar{A}_1A_0B_1B_0 + A_1\bar{A}_0\bar{B}_1\bar{B}_0 + \bar{A}_1\bar{A}_0\bar{B}_1B_0 + A_1A_0B_1\bar{B}_0$$

the interface circuit

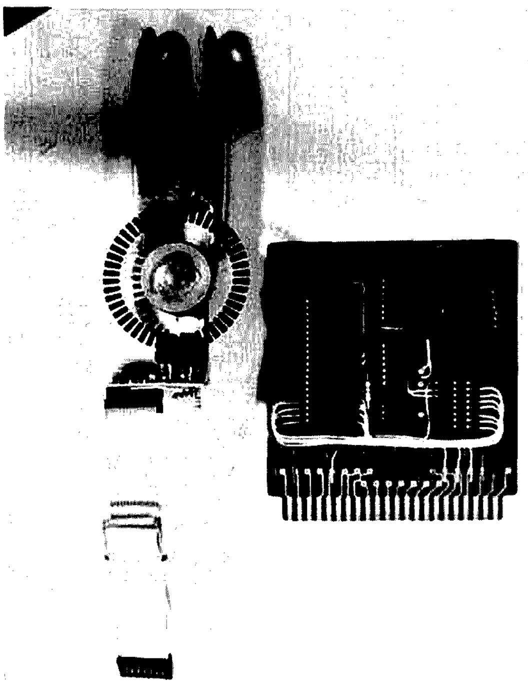
Fig. 2 is a schematic for one application card of the Intelligent Controller.[3] The darlington output of each optical interrupter is buffered by 7414 hex schmitt inverters. This buffer provides hysteresis to prevent jit-



SAMPLE TIME	LEFT MOTION	RIGHT MOTION
	A B	A B
T0	1 1	1 1
T1	1 0	0 1
T2	0 0	0 0
T3	0 1	1 0
T4	1 1	1 1

PASSAGE OF ONE COMPLETE MARK & SPACE

fig. 1. Encoder optical interrupter detectors relative to encoder disk and resulting logic states. Logic 1 is a mark seen by the detector, logic 0 a space.



The application card and one rotary dial assembly. Optical interrupters are visible at the disk bottom, just above the bracket for the ribbon cable DIP socket. The large chip on the card is the 8255 PPI with hex inverters at top center. Other card components are for another application not described here. The clamp is for photographic support of the dial assembly.

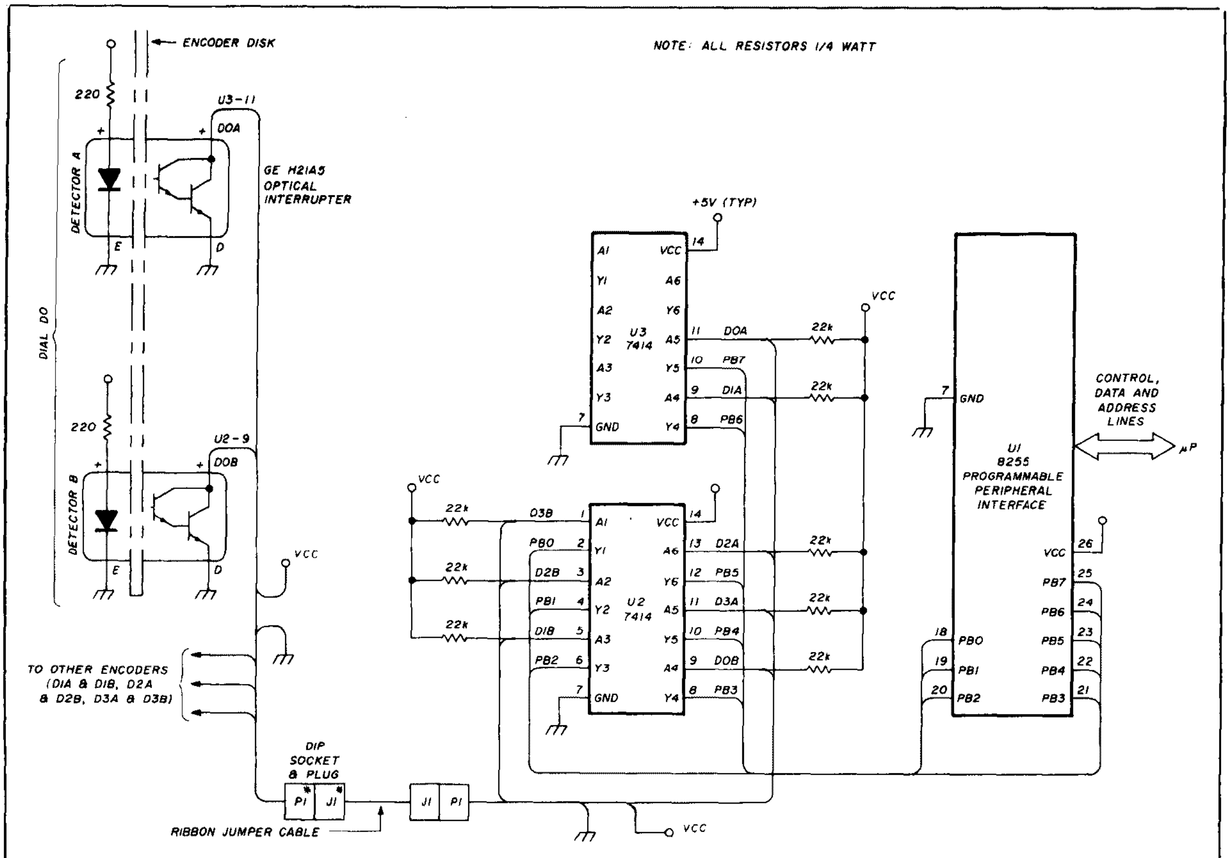


fig. 2. Schematic of the four-dial application card for the Intelligent Controller. The optical interrupter circuit may be repeated for three additional dials.

ter when an interrupter is near a dial mark edge.

An Intel 8255 Programmable Peripheral Interface (PPI) is the link between the inverters and the Intelligent Controller's HAM BUS. The 8255 was chosen because it is compatible with other system components, readily available, and one of the least expensive input/output (I/O) devices available.

The PPI is shown with connections to port B. Each 8255 has three ports, and the remaining two ports may be used for other functions in the Intelligent Controller.

motion algorithm

This algorithm was developed for a 6502 microprocessor but is of general nature and should work equally well on other microprocessor systems. General flow for motion sensing is shown in **fig. 3**, and is executed once every two milliseconds. Any state change detected due to dial motion will call the process subroutine detailed in **fig. 4**.

Twelve bytes of storage are required by both routines. Three are temporary, for scratch-pad storage, labelled TEMP1, TEMP2, and TEMP3 on the charts. OLDIAL holds the status of all four dials from the previous poll. Four bytes are the old dial logic (ODL) registers, one for each dial. The remaining four are direction registers (one for each dial), to indicate dial position.

Direction registers may be used in a service routine to remember dial motion. In my application they indicate positive ($01 to $7F) on the increments and negative ($80 to $FF) on decrements.

The microprocessor program allows other tasks to be executed between dial readings. Details on the flow charts and program operation are found in the appendix.

construction

As a disclaimer, I am more impressed with K3CU's mechanical construction than my own. For breadboarding purposes, I used parts taken from a ten-turn pot for its shaft and bushing. The dial and optical interrupters were mounted on a small piece of unetched PC board stock. It is very desirable to

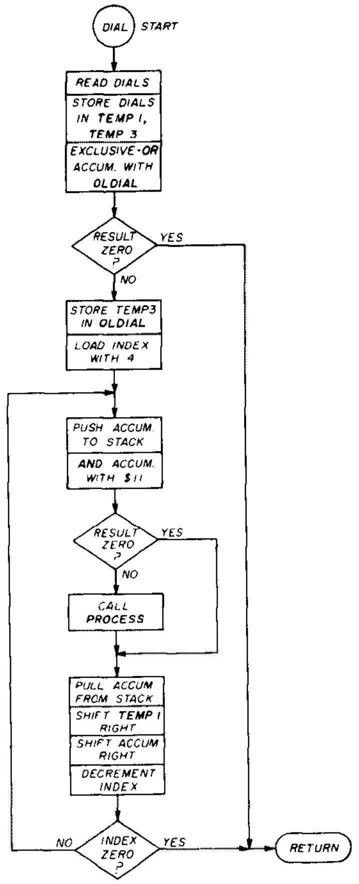


fig. 3. Flow diagram of the dial polling routine.

mount the interrupters with the shaft bushing for proper optical adjustment.

The dial subassembly holds a 16-pin DIP socket for interconnection to the application card. Flat-cable DIP plug cables are readily obtained. (Mine was an 18-inch (46 cm) cable from Radio Shack, part number 276-1976.)

I made the encoder disk in two steps: first I made a photocopy from the optical mask in **fig. 1** of Opal's article, then transferred it to a thermal-contact transparency. This gives satisfactory results, but you can purchase finished disks directly from K3CU.*

Opal suggested cementing the disk to a large knob for support. I soldered a circular piece of PCB stock to the shaft and attached the disk with rubber cement. My technique takes less space, while Opal's is easier.

The exact location of the optical interrupters is not critical. The illuminator center should be near the mark mid-radius. Once assembled, the relative interrupter positions can be set by bending the leads. Two cautions: keep the interrupter leads long enough and be careful not to pull off the PC board foil.

The dial shaft should have some friction device to prevent drift or coasting. I included a short piece of helical compression spring between bushing and encoder disk. This takes up any axial play and provides the necessary friction.

The inverters and PPI were mounted on a Radio Shack prototype board (part number 276-157). This is compatible with the intelligent controller. The extra chips seen in the photo are to support a Morse keyboard. The two spare 8-bit ports of the PPI may be used for other purposes.

operation

I had some initial problems providing sufficient signal for inverter inputs. I believe the interrupter collector resistor values given in **fig. 1** to be adequate for variations in both the interrupters and inverters. To make certain, the inverter and interrupter outputs can be checked with a high-impedance voltmeter. Inverter output should be low when interrupter output is high, and vice versa.

I wrote a simple program to drive a display for 256 counts to test the device. Depending on the spacing between interrupters, the count may go in either direction. The proper direction is obtained by repositioning the interrupters or modifying the service routine. I prefer the latter, having had some bad experiences with interrupter leads and foil peeling on the encoder subassembly.

Program documentation and burned 2716 EPROMs for the Intelligent Controller are available from the author. Please send a self-addressed, stamped envelope for information.

acknowledgment

The author wishes to express appreciation to Chet B. Opal, K3CU, for his comments and review of this article.

references

1. Lester A. Earnshaw, "A Tunable Synthesizer," *ham radio*, November, 1978, page 18.

2. Chet B. Opal, K3CU, "Rotary-Dial Mechanism for Digitally Tuned Transceivers," *ham radio*, July, page 14.

3. C.A. Eubanks, N3CA, "An Intelligent Controller for Ham Gear," *ham radio*, October, 1982, page 12, and November, 1982, page 25.

appendix

The flow chart details presented here will be useful if you are interested in converting to a microprocessor other than a 6502 or are not familiar with programming.

*Photo disks are available from K3CU for $1.00 each. Please send SASE to Chet B. Opal, K3CU, 5414 Old Branch Avenue, Temple Hills, Maryland 20748.

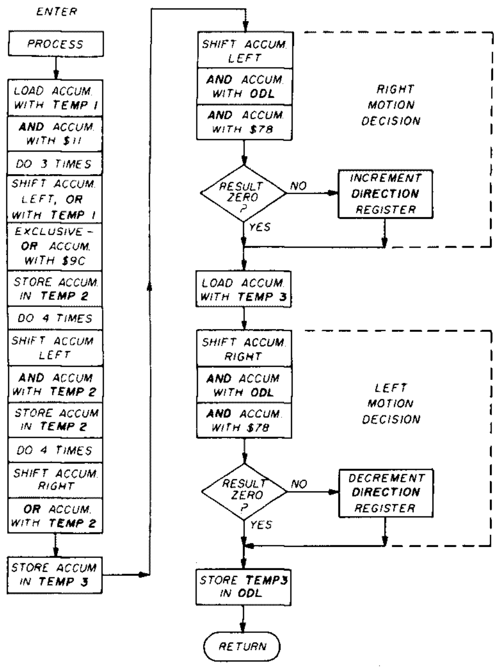


fig. 4. Flow diagram of the process subroutine to determine dial motion.

The dial routine in fig. 3 is invoked by a two-millisecond timer interrupt in the Intelligent Controller. This routine reads the status of all dials and compares that status with the previous status stored in the OLDIAL register. If there is no charge, the routine returns from processsor interrupt.

Change of dial input is indicated by one or more bits set to logic 1 after the exclusive-OR with OLDIAL. Each dial is then polled in a loop. The loop starts with dial status in the accumulator as follows:

$$A_0\ A_1\ A_2\ A_3\ B_0\ B_1\ B_2\ B_3$$

The accumulator is first pushed onto the stack (temporarily saved), then masked by ANDing with a bit pattern of 00010001 ($11 in hexadecimal notation). The result, on the first loop pass, will have A_3 in bit 4, B_3 in bit 0, and all other bits zero. If all bits are zero, *no change in that dial occurred*, the accumulator is restored by pulling it from the stack, and the accumulator is shifted right once. The index register (loop counter) is decremented, tested, and program flow continues at the loop start.

The purpose of right-shifting the accumulator is to provide separation in the $11 AND for the next dial. The second loop pass will have A_2 in bit 4, B_2 in bit 0. Each loop pass will test individual dials in decreasing order.

Any non-zero result of the AND accumulator with $11 will jump to the process subroutine shown in **fig. 4**. Entry to this subroutine will have TEMP1 holding an individual dial status in bits 4 and 0. Another mask with $11 is assurance that the three accumulator left-shifts and ORs with TEMP1 will have an individual dial input arranged as:

$$A\ A\ A\ A\ B\ B\ B\ B$$

The accumulator is exclusive-ORed with a bit pattern of 10011100 or $9C. The result of the exclusive-OR will set up the accumulator for subsequent testing of motion direction. Logic representation in the accumulator is now:

$$\bar{A}\ A\ A\ \bar{A}\ \bar{B}\ \bar{B}\ B\ B$$

Bit patterns in the accumulator will be as follows for the four possible optical interrupter state combinations:

$$A\ B = 01100011 \qquad \bar{A}\ B = 10010011$$
$$\bar{A}\ \bar{B} = 10011100 \qquad A\ \bar{B} = 01101100$$

Only one pattern will exist for one dial, stored in TEMP2.

The next two instructions set the accumulator to hold a logic 1 in one of the higher four bits for one of the previous state combinations. This is done by left-shifting the accumulator four times, then ANDing with TEMP2. The next two instructions (four right-shifts and OR with TEMP2) will duplicate the higher four accumulator bits into the lower four. The accumulator is now set for motion determination and is stored in TEMP3. The accumulator and TEMP3 will have one of the following bit patterns dependent on dial status:

$$A\ B = 00100010 \qquad \bar{A}\ B = 00010001$$
$$\bar{A}\ \bar{B} = 10001000 \qquad A\ \bar{B} = 01000100$$

One of these bit patterns will be loaded into a dial's ODL on subroutine exit.

The first motion decision occurs when the accumulator is shifted left once, then ANDed with the existing ODL (from a previous subroutine call). The result is ANDed again with 01111000 ($78) to strip any extraneous bits. If the second AND yields a non-zero accumulator, right motion was detected and the direction register for that dial is incremented.

The second motion decision is made by loading the accumulator with TEMP3, shifting the accumulator right once, then ANDing with the existing ODL. The second AND with $78 strips any extraneous bits. A non-zero result indicates left motion and the direction register is decremented. The final operation is updating the ODL with the current dial logic stored in TEMP3.

A key element in motion decision is the direction of accumulator shift prior to ANDing with the ODL register. This can be seen by examining the logic expressions in **table 1**, or the following state-change progression:

Right motion: $AB \to AB \to AB \to AB \to AB \to$
Left motion: $\bar{A}\bar{B} \to \bar{A}B \to AB \to A\bar{B} \to \bar{A}\bar{B} \to$

The current state combination must always be compared to the previous one.

Any out-of-sequence state combination will pass through the subroutine without effect on the direction register. Start-up may produce an arbitrary bit pattern in the ODL register byte and may cause an increment or decrement of the direction register; only one change occurs since subroutine exit will update ODL to the new dial logic. Set-up prior to motion decision ensures a minimum number of direction register glitches.

Each left-shift assumes a zero entering the least-significant bit. Each right-shift assumes a zero entering the most-significant bit. 6502 coding uses ASL and LSR instructions, respectively. TEMP3 is the Y-register of the 6502 with the X-register used as an index for each ODL and direction register in RAM.

Calculated execution time of the four-dial program in the Intelligent Controller is 141 μs with no dial change, 355 μs with one dial change, and 436 μs with two dial changes. Clock period is one microsecond and there is adequate time between 2-millisecond interrupts to execute other tasks in the controller program.

ham radio

HAM CALENDAR — December

SUNDAY	MON	TUES	WED	THUR	FRI	SATURDAY
W1AW Schedule April 25-October 24, 1982 MTWThFSSn = Days of Week Dy = Daily W1AW code practice and bulletin transmissions are sent on the following schedule. EDT Slow Code Practice MWF: 9 A.M., 7 P.M., TThSSn: 4 P.M., 10 P.M. Fast Code Practice MWF: 4 P.M., 10 P.M.; TTh: 9 A.M.; TThSSn: 7 P.M. CW Bulletins Dy: 5 P.M., 8 P.M., 11 P.M., MTWThF: 10 A.M. RTTY Bulletins Dy: 6 P.M., 9 P.M., 12 P.M., MTWThF: 11 A.M. Voice Bulletins Dy: 9:30 P.M., 12:30 A.M. CDT Slow Code Practice MWF: 8 A.M., 6 P.M.; TThSSn: 3 P.M., 9 P.M. Fast Code Practice MWF: 3 P.M., 9 P.M., TTh: 8 A.M., TThSSn: 6 P.M. CW Bulletins Dy: 4 P.M., 7 P.M., 10 P.M.; MTWThF: 9 A.M. RTTY Bulletins Dy: 5 P.M., 8 P.M., 11 P.M.; MTWThF: 10 A.M. Voice Bulletins Dy: 8:30 P.M., 11:30 P.M. PDT Slow Code Practice MWF: 6 A.M., 4 P.M.; TThSSn: 1 P.M., 7 P.M. Fast Code Practice MWF: 1 P.M., 7 P.M.; TTh: 6 A.M.; TThSSn: 4 P.M. CW Bulletins Dy: 2 P.M., 5 P.M., 8 P.M., MTWThF: 7 A.M. RTTY Bulletins Dy: 3 P.M., 6 P.M., 9 P.M., MTWThF: 8 A.M. Voice Bulletins Dy: 6:30 P.M., 9:30 P.M.			**BBC CELEBRATION** – Commemorating the 50th anniversary of the Empire Service in conjunction with the Ariel Radio Group – 1-31* **BOREALIS ARC SPECIAL EVENT** – Will present the Worked All North Pole Certificate from Fairbanks, AK – 1-31* **1**	**2**	**ARRL 160-METER CONTEST** – 3-5 **3**	**ANNUAL HANDI HAM WINTER HAMFEST** – Held at the Eagles Club in Faribault, MN. For more info contact W0FIT, 1114 Frank Ave., Albert Lea, MN 56007 – 4 **EVERGLADES ARC OPERATING EVENT** – Celebration of Everglades National Park – 4-5* **AOXA ANNUAL MEETING & BANQUET** – Sponsored by the Arkansas DX Association at the Ft. Smith Ramada Inn. For more info contact Harold Wilson, 3507 Lochlane, N. Little Rock, AR 72116 – 4 **TELCO PIONEERS QSO PARTY** – 4-6 **4**
17TH ANNUAL HAZEL PARK ARC SWAP & SHOP – Held at the Hazel Park High School in Hazel Park, MI. For more info send SASE to Hazel Park ARC, P.O. Box 368, Hazel Park, MI 48030 – 5 **ARGONNE ARC COMMEMORATION TO NUCLEAR EXPERIMENT** – To be held on the University of Chicago campus – 5* **5**	**WEST COAST BULLETIN** – 9 PM PDT (8PM PST, 0400 UTC), 3540 kHz, A-1 22 WPM – 6 **6**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **7**	**8**	**TRIPLE STATES RAC OPERATING EVENT** – Operating out of Bethlehem, WV – 9* **9**	**ARRL 10-METER PARTY** – 10-11 **10**	**K1BCI C/Q RADIO CLUB SPECIAL EVENT** – Honoring the anniversary of the Christmas Village in Torrington, CT – 11-19* **11**
12	**13**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0300Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **14**	**15**	**16**	**SPECIAL CHRISTMAS EVENT** – Sponsored by the Switzerland of Ohio ARES in Jerusalem, Ohio – 17-19* **17**	**18**
SANDY RIVER ARC OPERATING EVENT – Operating from Farmington, ME, to celebrate Chester Greenwood Day – 19* **19**	**WEST COAST BULLETIN** – 9 PM PDT (8PM PST, 0400 UTC), 3540 kHz, A-1 22 WPM – 20 **20**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **21**	**22**	**23**	**24**	**25**
26	**27**	**AMSAT** East Coast Net 3850 kHz 8PM EST (0100Z Wednesday Morning) **AMSAT** Mid-Continent Net 3850 kHz 8PM CST (0200Z Wednesday Morning) **AMSAT** West Coast Net 3850 kHz 7PM PST (0300Z Wednesday Morning) **28**	**29**	**30**	**31**	

*SEE COMING EVENTS

a 40-meter transmitter-receiver

Useful construction hints for a versatile, complete package

A 40-meter transmitter and **receiver** using semi-break-in keying is described in this article. It uses transistors in all the circuits except for the final tube, driver and T-R switch.

This article indicates problem areas and cures. Many hobbyists like myself build circuits acquired from handbooks and magazine articles and they don't always work. During construction things change. Perhaps the layout, perhaps a fine copper short on a PC board which can only be seen with a magnifying glass. I have spent hours searching for opens on parts which appeared to be soldered only to find no connection actually existed. I now scrape all component leads before I solder to ensure good electrical contact.

Access to parts represents another variable and the constructor must choose from his collection or from other sources. For example, I had silver-plated, nylon-covered wire available which I used for the VFO coil. It works quite well and provides stable VFO operation.

PC board construction

Printed circuit board construction takes practice and experience. I start by cutting the copper PC board with a hacksaw, holding the board in a vise between two pieces of angle iron. I smooth the edges and rub the surface of the copper with steel wool until it's bright. Black paper tape and drafting dots are used for circuit layout, and I keep a pencil sketch of the work. The dots and holes are center-punched. The board is placed in a cut-out milk container and ferric chloride solution is poured over it. Fresh etching solution is used each time since it weakens after several applications. A 75-watt lamp, placed over the container, hastens the etching process. I use steel tweezers to turn the board and pick it up because the solution can stain your fingers badly. Don't spill or drop any of it on the floor or sidewalk — it won't come off!

After the board is etched and washed the tape is removed and cleaned with paint thinner and the board is rubbed with steel wool again. Sometimes I put the board in a tinning solution if I have any on hand. If not, I hot solder-wipe the board. Holes are made with a number 60 drill and parts mounted and soldered one at a time with the board secured in a vise. Always check the board after you are done wiring. Run a scribe between the segments and look at the board with a magnifying glass. This sounds like a small point but can prevent problems such as shorts and open circuits.

Making boards by hand may seem to be time-consuming, but you will find it is fun and a good way to build. More elaborate methods include making negatives of the artwork and exposing photo-sensitized copper plates. However, that is a more expensive technique.

Occasionally, breadboarded circuits do not perform when printed on copper boards. Once again poor layout should be suspected. Above all, don't try to build an entire circuit and expect it to completely work initially. Build and test one section at a time.

power supply

A good place to start is by building a power supply. I built two receivers with an inexpensive 18-volt rms transformer using an LM 340-T regulator IC. The first two units worked. However, after constructing the third unit all the LM 340-Ts self-destructed though neither a capacitive nor resistive load had yet been connected. Exchanging the T unit with an LM 340-k-12 apparently solved the problem. An added benefit of this change was a total elimination of audio motor-boating. (A better transformer had also been introduced).

By Ed Marriner, W6XM, 528 Colima Street, La Jolla, California 92037

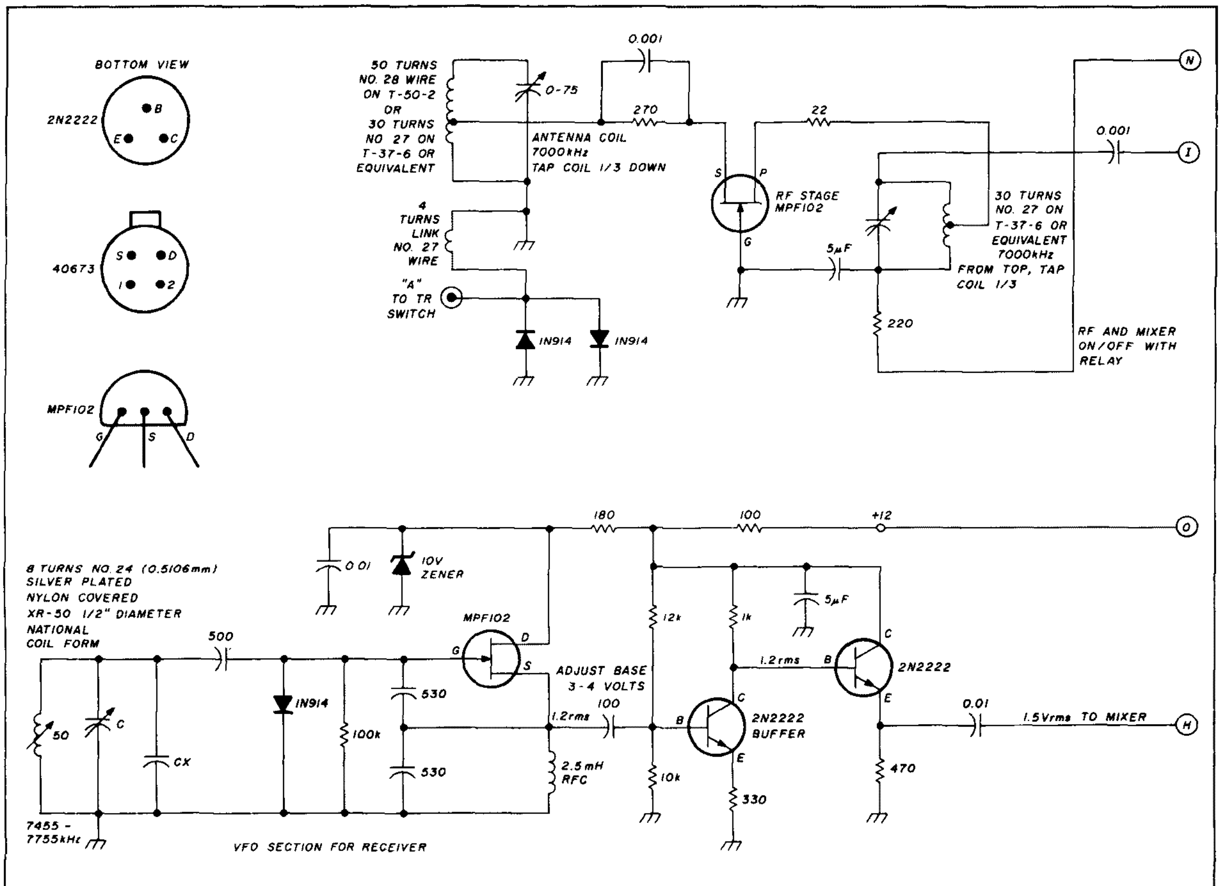


fig. 1A. Schematic diagram for the 40-meter transmitter-receiver.

Some experimenters use batteries (12-volt storage or Ni-Cds) to independently power their circuits. It also helps pinpoint causes of hum, unwanted oscillations and audio motor-boating. It's a good idea to run all the stages to a separate point, isolating each power lead with a 100-ohm resistor and five or more microfarad by-pass capacitors. This prevents inter-stage coupling.

audio amplifier

Now you have a working power supply, the next logical circuit to build is the audio stage. LM 380N chips work well and provide sufficient audio output. A 0.1 μF capacitor on the input pin prevents hum when the volume control is lowered.

A common practice is to use between two and ten microfarad capacitors for coupling audio stages. I found the audio stage would block with this large a value and reduced it to 0.02 μF. For CW low-frequency coupling is not necessary. The audio stages in this set are left on at all times to enable sidetone oscillator injection for CW monitoring.

product detector

A 40673 MOSFET is used as a detector and gain element. It eliminates the need for another i-f stage. Sufficient CW signal output is obtained from the mixer when a 1.5 V rms BFO level is injected. The 1k resistor and 0.05 microfarad capacitors form a filter that suppresses high frequency hiss (a mixer by-product), preventing its introduction into the audio stages.

bfo

A crystal BFO is simpler to build than a variable one. However, it is more difficult to make the 453.5 kHz crystal stage oscillate. After some research, the circuit in **fig. 1.** was tried. By placing an rf choke in the collector lead, and adjusting the capacitors from base to ground, the oscillator provided 10 volts rms output. I used a variable capacitor to experimentally determine the optimum values (200 pF from base to ground and 70 pF from collector to ground). The transistor oscillated only when the emitter was not grounded.

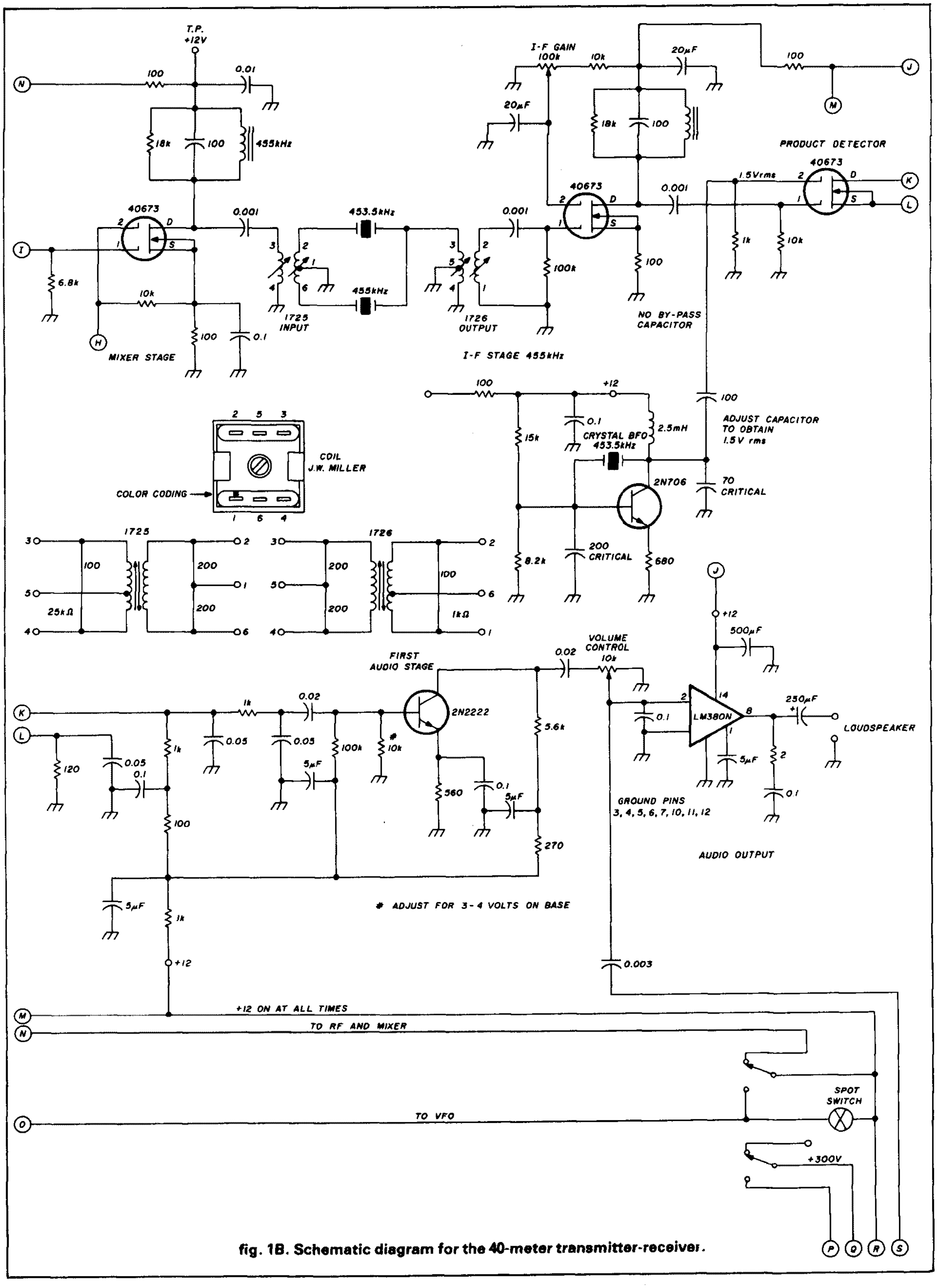


fig. 1B. Schematic diagram for the 40-meter transmitter-receiver.

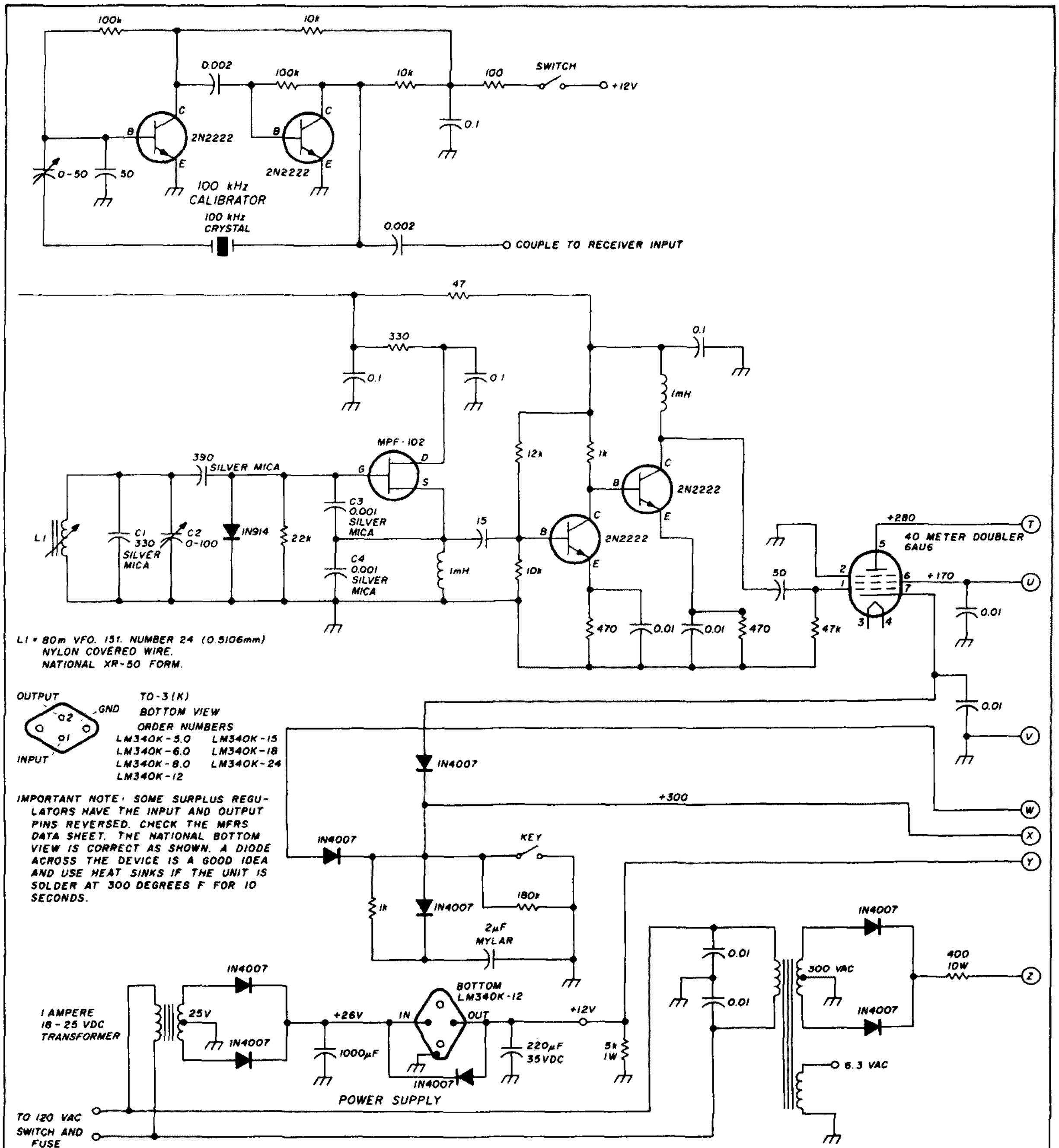


fig. 1C. Schematic diagram for the 40-meter transmitter-receiver.

i-f stage and filter

I-f filters are expensive and hard to find. A CW and SSB filter can be constructed using two low-frequency crystals, one at 455 kHz and the other at 453.5 kHz. The J.W. Miller crystal-matching i-f transformers, types 1725 and 1726, complete the crystal filter assembly. The transformers can be mounted on a PC board and must be grounded. Care must be observed when tuning the i-f slugs. Do *not* screw the slug in too far or it will damage the internal wiring. Peaking is accomplished by listening to off-air signals or by feeding in a 455 kHz signal.

The i-f stage transformers are small potted toroids which resonate at 455 kHz with a 100 pF capacitor. A J.W. Miller 330 microHenry unit also works. A paral-

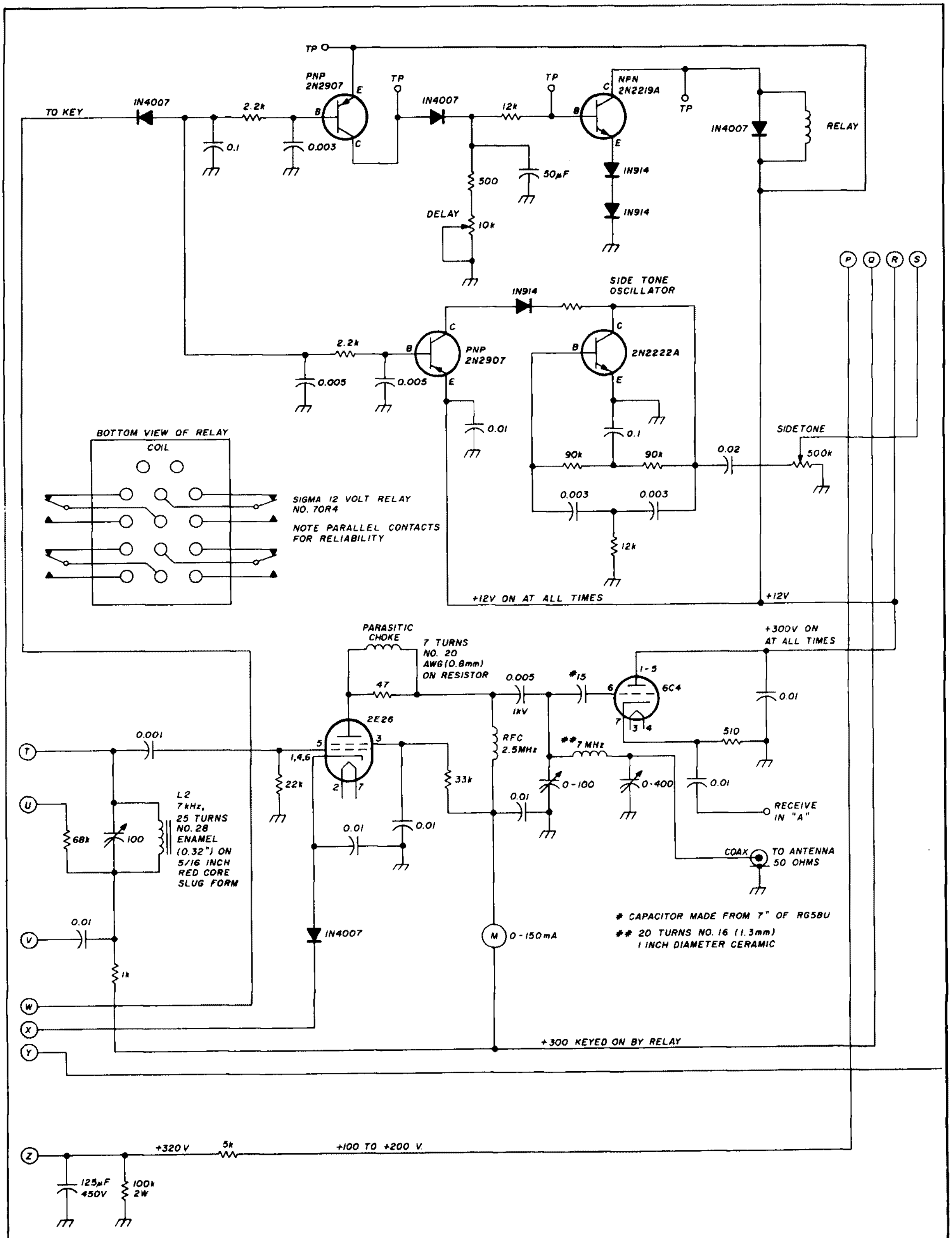


fig. 1D. Schematic diagram for the 40-meter transmitter-receiver.

Parts List	
coils	*J.W. Millar Co., 19070 Reyes Ave., Compton, California 90224.*
semi-conductors	*Semiconductors from Circuit Specialists, Box 3047, Scottsdale, Arizona 85267 or telephone 1-800-528-1417.* *Some semi-conductors can be found at Integrated Circuits Unlimited, 7889 Clairemont Mesa Blvd., San Diego, California 92111.*
printed circuit tape	*Drafting tape for printed circuits. Mesa Design Reprographics, 4925 Convoy St., San Diego, California 92111, telephone 714-565-4724.*
dots	*Dots are called donut pad D144 for .150 od × .031 inch (3.81 mm × 0.79 mm).*
tape	*I use Bishop precision slit tape #201-250-11 which is .250 inch wide (6.35 mm).* *Tape 201-125-11, .125 inch (3.18 mm).* *Also some .062 inch wide tape is useful. The tape comes in all widths, from Bishop Graphics, Westlake Village, California 91359.*
toroids	*Amidon Associates, 12033 Otsego St., North Hollywood, California 91607.*
i-f coils	*Radio Shack sometimes has an assortment bag of coils. Check here for i-f coils. Those used in this set were potted in ceramic, red color and have two leads projecting out. No number for stock.*
etching	*Try WA3OJF, PO Box 398, New Cumberland, Pennsylvania 17070. You can get mixed solution at your local chemical supply house.*

leled 18k resistor reduces the Q and chance of oscillation. The FET's source by-pass capacitor was left off to reduce the possibility of self-oscillation in the i-f stage.

rf and mixer stage

The rf and mixer stage is keyed by the relay for semi-break-in. Amidon (red) toroids are satisfactory for the coils as long as they resonate on 40 meters. Slug-tuned coils can be used as well. However, it is easier to tap down on toroid windings. The idea here is to sharpen the tuning without loading the circuit too heavily.

1N914 diodes inserted back-to-back on the antenna link coil reduce the rf if it exceeds 1 volt. The T-R switch reduces the transmitter leak-through rf level to about 2 volts.

vfo

A Colpitts' configuration is preferred for the receiver VFO. The 500 pF coupling and two fixed 530 pF capacitors are appropriate values needed for oscillation. The tuning capacitor, affected by these capacitors, requires careful matching for specific range coverage. The MFP-102 transistor stage provides 1.4 volts, enough to drive the buffer and emitter follower. This circuit eliminates frequency pulling by reducing mixer influence. The base voltage on the buffer is adjusted to read between 3 to 4 Vdc. This is accomplished by carefully selecting the 12k and 10k resistors. The 1.5 volts from the crystal filter provide one of the mixer inputs. Its injected level determines the mixer output.

transmitter

The transmitter VFO was designed for 80-meter operation to prevent 40-meter rf interference. The VFO is actuated when the relay closes. Better performance is achieved using this technique rather than keying the VFO directly. Drive is increased by placing an rf choke in the collector lead and taking the output from the collector rather than from the emitter. The emitter by-passing increases the rf drive to the 6AU6 doubler on 40 meters. The 6AU6 provides enough drive to the 2E26 with 300 volts on the plate. When lightly-loaded, the 2E26 plate has a pronounced tuning dip if sufficient drive is applied. The 6AU6 and 2E26 output stages are keyed and isolated by 1N4007 diodes. The keyed semi-break-in and sidetone circuits are also isolated from each other by diodes. A keying network, introduced by VU2JN, produces a clickless signal.

relay circuit

When the key is closed a positive pulse is transmitted to the 2N2219A base. The two 1N914 diodes ensure 2219A cutoff when the key is released. The diode across the relay eliminates any hang-up problems. The relay hold-in time is determined by the delay potentiometer and the 50 μF capacitor. A positive voltage, from the sidetone keyer, applied to the base of the 2N2222 turns it on. The sidetone oscillator, which provides a clean, adjustable level, monitoring signal, is lightly-coupled to the LM 380N input.

ham radio

data bandwidths compared

Bandwidth requirements for four competitive data modulators

With increasingly crowded Amateur bands, will hams begin using more sophisticated digital-data modulation schemes in the future? FSK (frequency-shift keying) is the predominant modulation scheme used to transmit data in the Amateur service; but this may not always be the case, because there are several other possible schemes which are better than FSK in some ways. This article will compare the bandwidth requirements for four competitive methods of modulation data.

It is in our interest to use our limited spectrum space as efficiently as we can. I will be discussing FSK, CW, and two forms of PSK (phase-shift keying), that is, two-phase PSK, also called Binary PSK, or BPSK; and four-phase PSK, also called Quaternary PSK, or QPSK.

the fast-Fourier transform

In the discussion that follows, the signal spectra presented were generated by performing a spectrum analysis on a computer simulation of typical data modulated by each of the different schemes. This was done by creating a mathematical model of a data signal consisting of a sequence of 128 samples with 156 microsecond spacing and modulating it by each of the four methods. The results were then processed by a Fast-Fourier Transform computer program that produced a power spectra plot (showing energy content as a function of frequency) for each of the signals. I will not be discussing how this program operates, but only the results of this analysis.

The horizontal axis of each plot is frequency (in Hertz), and the vertical axis is the signal power for each frequency component in (dB relative to the strongest component). As a convenient reference, we will define the bandwidth of the signals as the band over which frequency components greater than − 15 dB relative amplitude are present. This standard will allow bandwidth comparisons between the different modulation schemes.

frequency-shift keying

FSK is the most popular data mode today because it is comparatively simple to generate and demodulate. The output frequency of the transmitter is shifted between one of two different frequencies (mark or space) depending upon the data bit being sent (0 or 1). The demodulator can be two simple filters, one for each of the frequencies, and rectifiers and a slicer to determine which frequency channel has the most energy at any time.

An FSK signal using 1200 Hz and 1600 Hz was modelled for this analysis, and a data rate of 400 BPS (bits per second) was used. (This is about the maxi-

By J.T. Dijak, W9JD/2, 215 Tareyton Drive, Ithaca, New York 14850

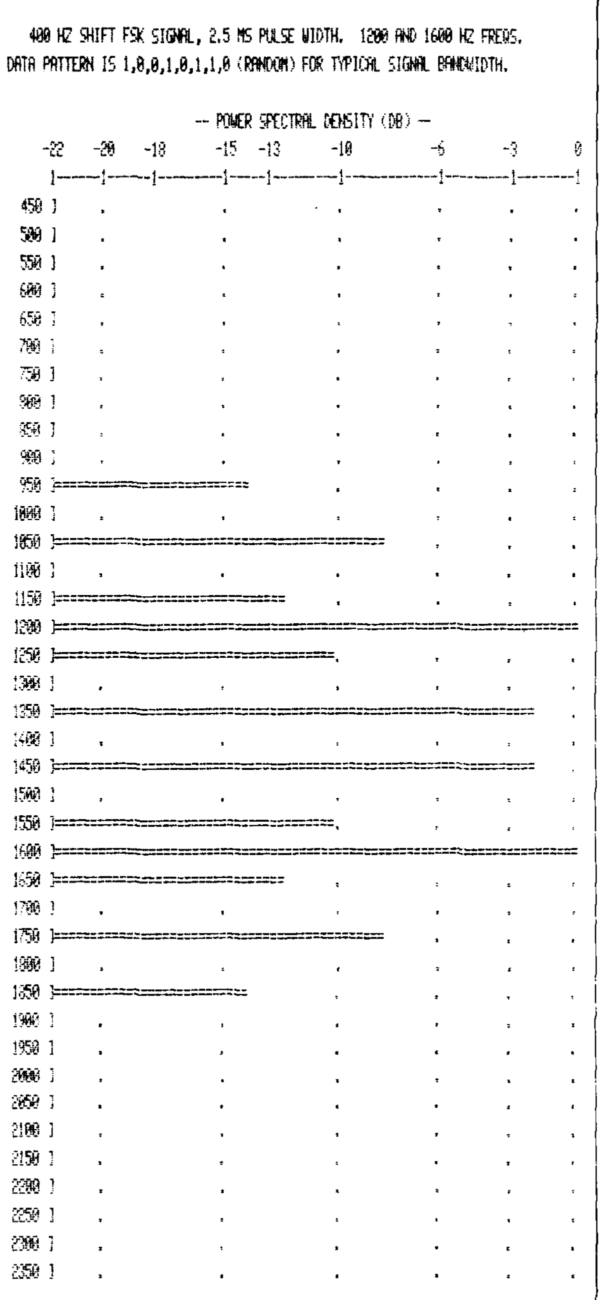


fig. 1. Analysis of frequency-shift keyed signal: the data rate of 400 BPS requires a bandwidth of 900 Hz, and provides moderate error protection.

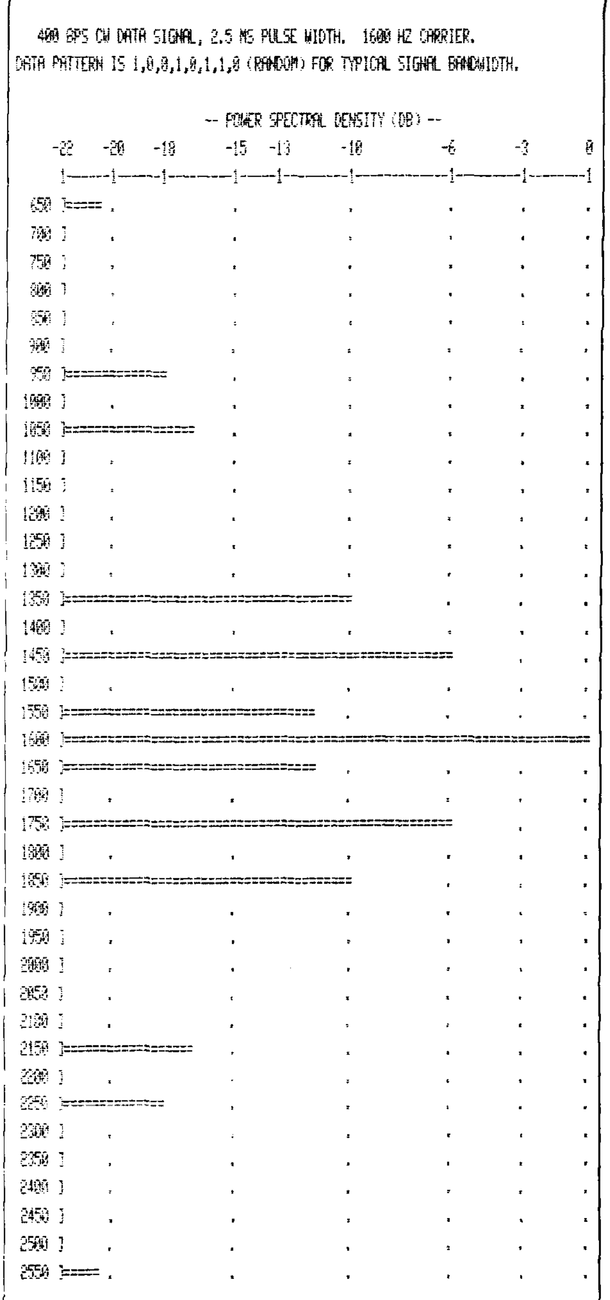


fig. 2. Analysis of CW signal: the 400 BPS data rate requires only 500 Hz bandwidth, but has an error rate worse than that of the FSK method.

mum reliable data rate that can be sent via FSK with a 400 Hz shift.) A sequence of eight data bits in a random pattern composed the signal sequence.

Fig. 1 shows the spectrum plot for the FSK signal. We can see that the frequency components extend only from 950 to 1850 Hz, which makes for a tightly knit signal of 900 Hz bandwidth. This is our first spectrum, and we will use it as a reference in discussing the others.

CW

We could also send data using a CW signal where

the presence of the signal could indicate a mark, and the absence, a space. This signal is also very simple to generate, and simple to demodulate. The error rate versus signal-to-noise ratio is not as good as that for an FSK signal, however. This is because it is easier to tell a mark from a space when we are considering two different frequencies than when we must determine the presence or absence of one signal in a noisy channel.

For this analysis, a CW signal at a 400 BPS data rate using 1600 Hz as the center frequency was used. The same data pattern used with the FSK signal was used with this signal.

Fig. **2** shows the spectrum plot for the CW signal. We can see that (considering only −15 dB components or greater) the signal bandwidth (500 Hz) is narrower than for the FSK signal. We can also see that there are now other components farther out from the carrier. We can expect a small amount of signal distortion in the demodulator if we use filtering to limit our bandwidth to something on the order of what was required for FSK.

It is reasonable to expect the CW data signal to show higher harmonic spectral components than the FSK signal. The FSK waveform had smooth transitions between mark and space bits. The only difference between the two signals was a difference in frequency, and the transitions were made at a zero-crossing of the signal. Therefore, there were no abrupt changes in the FSK waveform. The CW signal, on the other hand, imposes very abrupt changes in the signal when it goes from mark to space — from no signal present, to full signal present. We know that higher harmonic terms are required in a signal spectrum to accomplish any abrupt transition like this in the waveform.

BPSK

Binary PSK sends a continuous carrier at one frequency, but the phase of the signal is shifted 180 degrees for a space bit. This signal, while requiring more complicated modulators and demodulators than either FSK or CW, provides an error rate superior to either other mode for a given signal-to-noise ratio.

Fig. **3** shows the spectrum plot for the 400 BPS BPSK signal. The same data pattern used in the previous examples was again used. We can see that the BPSK signal is wider than either the CW or FSK signals. This is not a surprise, since we know the BPSK waveform has very abrupt transitions at the bit boundaries where the phase of the carrier signal goes from +180 degrees to 0 degrees. In order to reproduce these abrupt transitions, the signal requires the higher harmonic spectral components that we see.

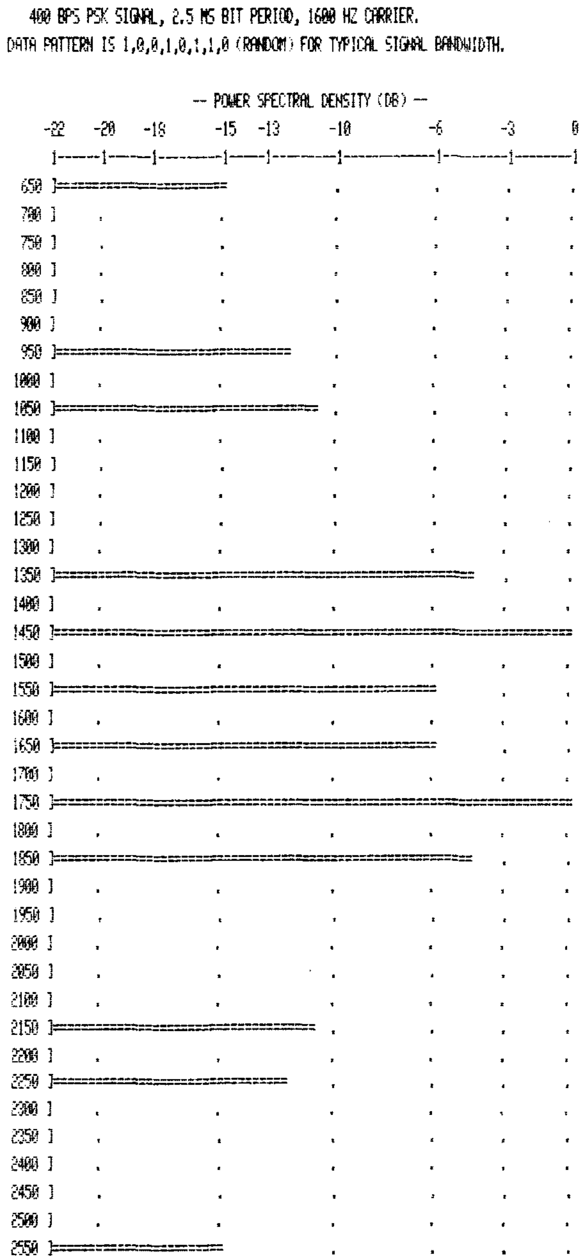


fig. 3. Analysis of binary phase-shift keyed signal: because of the high error protection provided by the BPSK method, the signal can be filtered to require less than 500 Hz bandwidth at 400 BPS; but the hardware required is more complex.

From this we can say that an unfiltered BPSK signal will require a wider signal bandwidth than CW or FSK for the same data rate; however, due to the superior synchronous detection process used (and required) with PSK, we can discard many of the

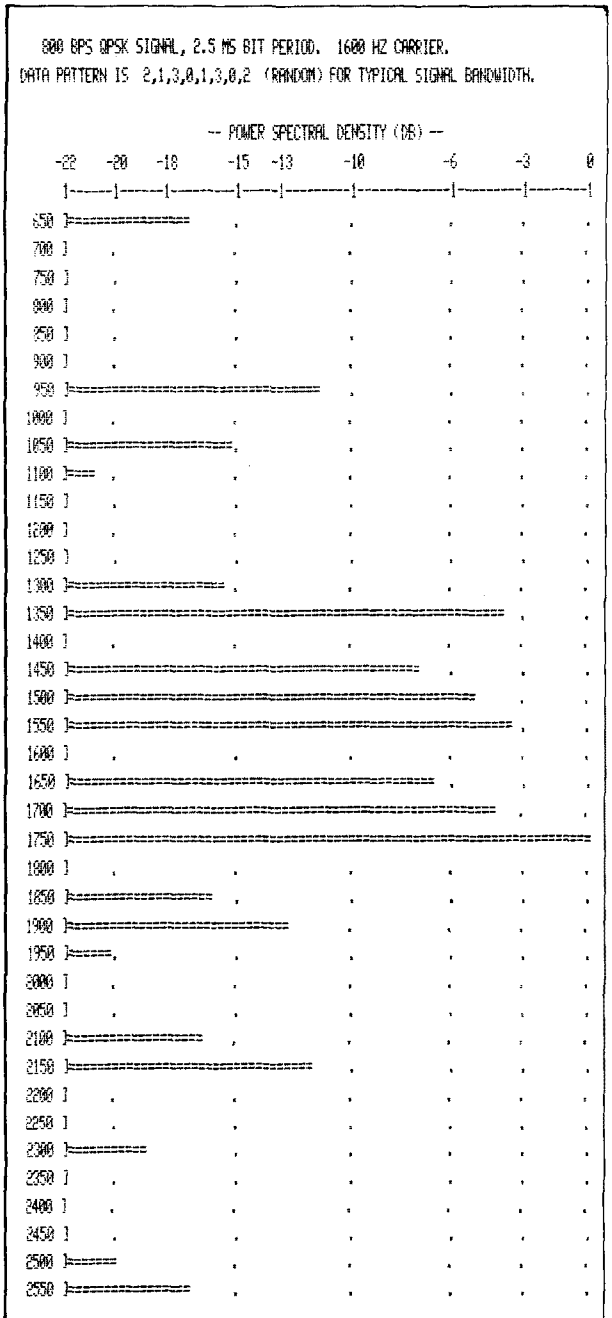


Fig. 4. Analysis of quaternary phase-shift keyed signal: because each bit in this system can have four states, filtered QPSK signals provide twice the data rate for the same bandwidth as the BPSK method (although the hardware is even more complex). The error rate is slightly worse than with the BPSK method.

higher harmonic spectral components (by filtering). This blurs the transitions between bits, but does not seriously disturb the most important signal information for each bit. We could use a filter at the transmitter to limit signal bandwidth to that required for FSK, and the detection process would still work well. Then, in exchange for the added complexity of the BPSK modulator and demodulator, we could obtain superior error-rate performance at the same data rate and in the same bandwidth as FSK.

QPSK

Quaternary PSK sends a carrier with one of four possible phase states at any time (that is, 0, +90, +180, or +270 degrees). Rather than sending one of two possible signals during each bit interval in the channel, we now send one of four possible signals, so each channel can be used to send two data bits (also called a di-bit). This is how a QPSK signal using a 400 BPS signalling rate in the channel can maintain an 800 BPS data throughput.

Fig. 4 shows the spectrum plot for an 800 BPS (throughput) QPSK signal — twice the rate for the previous examples — operating at a 400 BPS signalling rate in the channel. The spectrum looks somewhat similar to the BPSK spectrum, except that there are now several additional frequency components close-in near the carrier.

The higher harmonic components decrease in amplitude at a rate similar to those for the BPSK signal. We are sending di-bits through the channel at a 400 BPS rate, so we can again filter the transmit signal to pass only components within 400 Hz of the carrier and obtain good receiver performance. (In fairness, we must note, however, that QPSK does not exhibit error-rate performance as good as BPSK — this is because it is more difficult for the decoder to make the proper decision from the more complicated signal set.)

The main advantage of QPSK is that, assuming we can tolerate a slightly worse error rate than with BPSK, we can send twice the data rate while using the same bandwidth as BPSK or FSK. This is especially important in Amateur Radio VHF fm applications where we have good signal-to-noise ratios, but limited bandwidths.

summary

FSK is currently the most popular data-modulation scheme, due to its simplicity; but, when Amateurs become interested in better error-rate performance and maximum data throughput for a given signal bandwidth, they will probably start moving toward filtered BPSK or QPSK. This will be especially true at VHF and UHF where the frequency-diversity advantages FSK enjoys at high-frequency frequencies are much reduced.

ham radio

battery charge sensor

A small sensor that warns you before your Ni-Cds discharge

Many a nickel-cadmium cell has been destroyed by depletion of its charge below the protective voltage level.[1] As many Amateurs know, when a Ni-Cd cell is discharged to near zero voltage there is a good possibility the cell may take on a reverse charge. The reason for this is the small differences in capacitance between cells; the cell reaching full discharge first is reversed charged. This condition can be prevented if the protective voltage level is detected and the cell is recharged.

My slightly vintage crystal 2-meter rig (a Kenwood TR2200A) uses ten Ni-Cd AA cells arranged in a four- and six-pack as its power source. The rig does have provision for monitoring the voltage level of the battery pack using the combination RF/S/battery-meter. This is fine if you operate in enough light to read the meter, which is, even under best conditions, somewhat inconvenient and difficult to read. But suppose you have no light — such as on your patio in the evening or in the forest on a camping trip. The battery meter is not of much use under these conditions.

My solution to this problem is a sensor circuit designed to continuously monitor the battery voltage and detect the approaching protective voltage level. When this level is reached, the sensor activates an alarm, which in my rig flashes the built-in channel pilot lamp at a 1-Hz rate. I chose to set this voltage level to 11 Vdc, which allows some additional time after the alarm to end a QSO. The lamp will automatically stop flashing when, during charge, 11 Vdc is exceeded. The sensor circuit and lamp are powered in such a way that the main ON/OFF power switch will turn off everything.

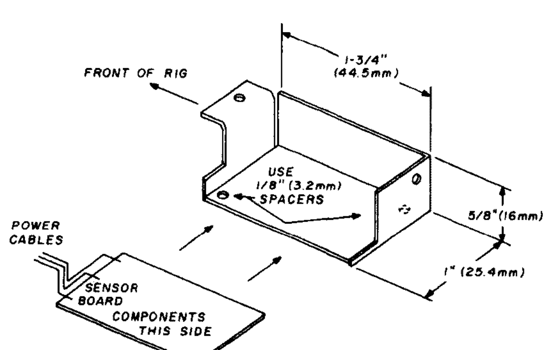


fig. 1. The battery compartment box, showing placement of sensor circuit board.

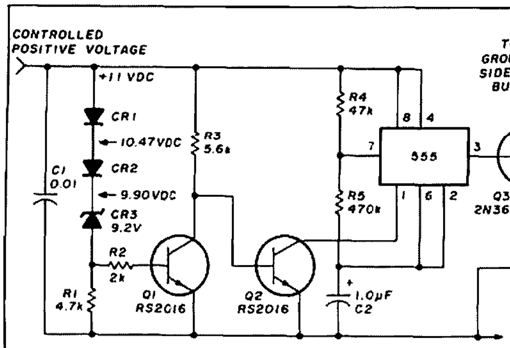
By F.T. Marcellino, W3BYM, 13806 Parkland Drive, Rockville, Maryland 20853

Because my 2-meter rig is a Kenwood TR2200A, placement of the sensor was not difficult. In the battery compartment, the manufacturer had installed a rectangular box to take up space next to the four-cell pack. The box is removable by taking out two Phillips-head screws. The inside measurements of the box are 1 × 1-3/4 × 5/8 inches, which lends itself to housing a miniature circuit board. **Fig. 1** shows the removable portion of the box and how I mounted a hand-wired circuit board in place. **Fig.** 2 is the circuit board showing layout of parts.

circuit description

Assume the Ni-Cd battery pack has a charge between 11 Vdc and full charge. Under those conditions, the zener diode, CR3, will be biased into its forward breakdown region, developing a voltage at the junction of R1 and R2. If this voltage is above 0.65 Vdc, Q1 will be saturated with its collector pulled down essentially to ground. This condition prevents Q2 from conducting, and so the ground pin No. 1 of the 555 will be held high near the battery voltage. The 555 will not start oscillating until pin 1 is grounded. The output of the 555 is pin 3 and it is internally held at the battery voltage at this time. A PNP transistor, Q3, is used to control the alarm/channel lamp. The lamp will light every time Q3's base is grounded — or flash if the base is pulsed to ground.

As the battery pack depletes itself and the terminal voltage approaches 11 Vdc, CR3, a 9.2-Vdc zener, will stop conducting because it is biased above ground by CR1, CR2, and the emitter-base diode of Q1. **Fig.** 3 shows the sensor circuit, including the zener voltage drops for battery levels of 11 Vdc to full charge. To achieve the proper protective voltage level it is necessary for CR1, CR2, and Q1 to be silicon devices. Germanium components will not do because of their lower forward bias voltages, placing the level far too low. When Q1 stops conducting, Q2 will saturate and ground pin 1 of the 555. At this time the channel lamp will begin to flash at a 1-Hz rate.



Except as indicated, decimal values of capacitance are in microfarads (μF); others are in picofarads (pF); resistances are in ohms.
k = 1,000 M = 1,000,000

fig. 3. Battery-charge sensor diagram with zener current path voltage drops.

The sensor circuit is composed of fourteen components plus the circuit board. With a typical ham's junkbox, the sensor can be produced for less than five dollars. The circuit requires three hard-wired connections to the rig: a power ground, a connection to the ground side of the channel lamp, and a controlled positive battery voltage.

Normal operation of the TR2200A's front panel lamp switch is not impaired by the sensor circuit. The channel lamp can be turned on at any time — even when the lamp is flashing. The standby current drawn by the sensor is 5 mA at a battery charging voltage of 13.6 Vdc and it tapers to 2.28 mA just prior to the lamp's flashing at 11 Vdc. These current levels are constant and do not change under transmit conditions. I consider this current drain a small price to pay for Ni-Cd reverse-polarity protection. In my rig the original standby drain was 45 mA, so an additional 5 mA amounts to slightly more than 10 percent.

One nice feature of this sensor is that it can be removed quite easily for resale purposes. The rig would regain its original unmodified status with no unwanted front panel holes. But once the purpose of the sensor has been explained to the buyer, he probably would gladly accept the rig with the modification included.

ham radio

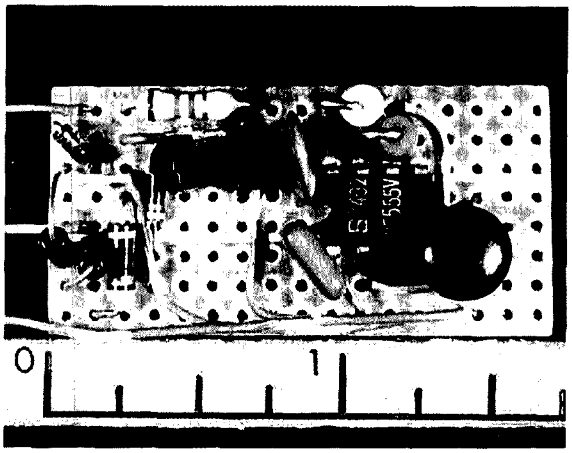


fig. 2. Sensor circuit board and parts layout.

reference

1. "Eveready Battery Applications and Engineering Data," Union Carbide Corporation, 1968.

ham radio TECHNIQUES

Bill Orr W6SAI

The fall antenna construction season is almost over and the winter months are close at hand. Not much time left this year for antenna experimentation!

Even so, here's some interesting and useful data on the inverted-V dipole antenna. This simple antenna is very popular. It has the forgiving characteristics of the dipole (easy to get into operation), it is inexpensive, a good radiator and it can be supported from a single center point.

This past summer some extensive tests were run on the inverted-V dipole by JA5COY (Japan) and were reported in a recent issue of *CQ-ham radio*, published in Tokyo.

JA5COY made measurements summarized in **fig. 1**. The first tests were on an 80-meter dipole (**fig. 1A**). The antenna exhibited a feedpoint impedance very close to 73 ohms, as expected, and the bandwidth between the 2-to-1 SWR points was about 330 kHz.

He then dropped the ends of the dipole to form an included angle of 120 degrees and repeated his tests (**fig. 1B**). The feedpoint impedance dropped from 73 ohms to 50 ohms and the bandwidth dropped to 310 kHz. In addition, the resonant frequency of the antenna dropped about 15 kHz.

The last experiment was to decrease the included angle to 90 degrees (**fig. 1C**). The feedpoint impedance dropped down to 30 ohms at resonance and the bandwidth further decreased to 210 kHz between the 2-to-1 SWR points of measurement. And, finally, the resonant frequency dropped about 35 kHz from that of the straight, horizontal dipole. Antenna height during these tests was not noted.

This is handy information, as it provides all that is needed for a pre-cut inverted-V dipole antenna. The summation is:

Dipole antenna:

Length for resonant frequency

$$= \frac{468}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 73 ohms.)

Inverted-V dipole antenna:

Included angle = 120 degrees

Length for resonant frequency

$$= \frac{465.6}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 50 ohms.)

Inverted-V dipole antenna:

Included angle = 90 degrees

Length for resonant frequency

$$= \frac{463.3}{f(MHz)}\ feet$$

(Feedpoint impedance approximately 30 ohms.)

As an example, suppose you want an inverted-V dipole for 80-meter phone operation to cover the range of 3750 to 4000 kHz. This is a span of 250 kHz. An antenna with an angle of 120 degrees included will do the job as it provides a bandwidth of about 310 kHz and — best of all — has a feedpoint impedance of about 50 ohms when mounted at a reasonable height above ground.

The mid-point of the chosen range is 3875 kHz, so the dipole is cut for this frequency:

$$\textit{Inverted-V dipole length} = \frac{465.6}{3.875}$$

$$= 120.15\ \textit{feet, or } 120\ \textit{feet, } 2\ \textit{inches}$$

(round it off to 120 feet).

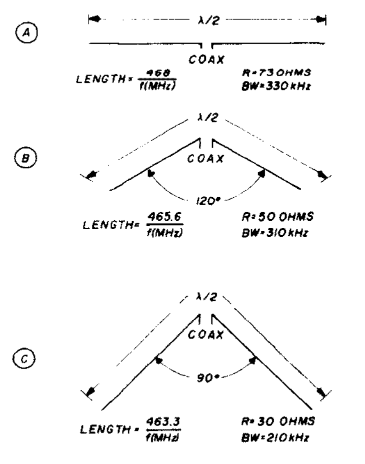


fig. 1. Comparison of feedpoint impedance (R) and bandwidth (BW) for dipole (A) and the two versions of the inverted-V dipole (B and C).

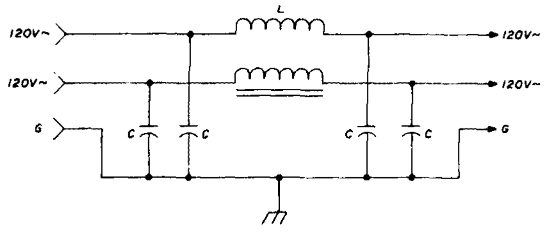


fig. 2. A simple line filter you can make. The dual winding coil (L) is composed of 20 bifilar turns No. 18 insulated wire, wound on a ferrite rod, 1/2-inch diameter. Rod is 61 nickel-zinc material having a permeability of 125 (J.W. Miller FR-500-7 or Amidon R61-050-750). Wires are wound in parallel and ends are held in place with twine and epoxy cement. Capacitors (C) are 0.01-μF ceramic units, rated for continuous operation at 125 Vac and can withstand surges to 1400 volts (Aerovox AC-7, Centralab CI-103 or Sprague 125L-S10). Filter is built on a metal plate bolted within an aluminum chassis which serves as a dust cover. (Filter data from *Interference Handbook*, by Nelson, published by Radio Publications, Inc., Box 149, Wilton, Connecticut 06897).

Thus, the dipole will be 60 feet on a leg, with an included angle of 120 degrees and should cover the complete 80-meter phone region with an SWR of less than 2-to-1.

The antenna can be zeroed-in for minimum SWR by raising or lowering the ends of the dipole. As in the case of any antenna, the presence of nearby metallic objects (power lines, TV antennas, etc.) may alter the performance and SWR a bit.

more about TVI and RFI

TVI and RFI seem to be a sore subject these days. More hams and more entertainment equipment is the prime factor, plus the fact that solid-state circuits, as used in home entertainment equipment, operate at a lower signal level than does the older, tube-style gear. Nevertheless, the Amateur operator should make sure his equipment is clean and a few simple preventive, anti-TVI steps should be taken *even if there is no TVI or RFI.* Better to be safe than sorry!

Cleaning up the exciter: at the very least, an rf line filter should be used with the exciter to prevent rf from finding its way into the primary power line. A simple and effective line filter, such as the J.W. Miller[1] C-508-L, or equivalent, will be satisfactory. In addition, the exciter should be grounded (more about this later).

Cleaning up the linear amplifier: an rf line filter should be used on the linear amplifier. J.W. Miller Co., and others, make suitable filters, or you can build your own. A practical filter is shown in fig. 2.

Your antenna system: you'll require a lowpass filter between your transmitter and your antenna. It should go in the 50-ohm coaxial line after all such devices as SWR meters or coaxial switches. That is, there should be nothing between the filter and the antenna except the interconnection line. Several makes of lowpass filters are available; a good one is the Barker & Williamson 425, rated at 1 kW.[2] (The model 424 filter is rated at 100 watts — just the thing for your exciter.) Both these filters are designed for 50-ohm coaxial systems.

Your ground system: the station ground is important, especially from the FCC point of view. If you are ever visited by the FCC or a TVI committee, one of the first questions they will ask is, "Is the transmitting equipment grounded?"

To protect yourself in this instance, you'll need a ground lead from the equipment to the nearest ground point: either a water pipe ground or an external ground rod driven into the soil.

From a legal point of view, this satisfies the *requirement.* But *I don't* have to tell you that such a ground is worthless as an rf ground. Unfortunately, a good rf ground is hard to get, unless your station is at ground level and the ground wire from the equipment to the ground is only a foot or two long! In most cases, this is an impossible requirement.

In my case, I am on the ground floor of my home. I connected all equipment (receiver, exciter, amplifier) together with flexible No. 10 insulated copper wire. *I* did not depend upon the shields of the coaxial interconnecting wires to do the job. The next step was to drill a small hole in the floor behind the operating table and drive an eight-foot (2.5 m) ground rod down into the earth through this hole, until only an inch of the rod protruded into the room. I then ran a No. 10 flexible wire from the equipment to the ground rod.

This provided a satisfactory ground on all bands except 10 meters. I found that I still had some rf floating around the equipment on that band, even though everything was supposedly at ground potential. I didn't want to drive another ground rod under the house (it was a terrible job), so I drove one into the ground at the point where my coaxial line came from under the house and passed across the yard to the antenna tower. I grounded the shield of the coaxial line to this ground rod and then, spurred on by over-enthusiasm, I drove a third ground rod at the base of the tower and tied the coaxial shield and the tower to this rod. In addition, I bypassed all the rotor control wires to the ground rod at the base of the tower.

That seemed to do the job. All equipment was rf-cold on all bands, I used a lowpass TVI filter for the transmitter and all power leads were filtered and bypassed. That should make my equipment TVI-proof. Did it?

cleaning up the TV receiver

The answer to the question, of course, is no. While my transmitting equipment was reasonably clean, both my TV receiver and those of my neighbors were wide open to strong local signals in the ham bands. My receiver (a ten year old RCA XL-100) turned black in the face when I went on the air with the linear amplifier — on any band!

When I removed the back from the set, the reason was apparent: a rat's nest of interconnecting wires running between printed circuit boards and no sign of any filtering or protective circuits. (The TV set was much worse, from a TVI point of view, than my previous one — an old tube model with very good internal shielding).

To clean up this receiver, it was necessary to use a line filter (J.W. Miller C-508-L), plus a good high-pass filter on the antenna ribbon line. One of the best filters is the J.W. Miller C-513-T3. This is a multiple section design enclosed in an aluminum box. It provides more low frequency attenuation than simpler filters.

The combination of the line filter and the high-pass antenna filter did the job. Now I could operate at full power on all bands below 30 MHz with no TVI. Eventually, I got Miller line and high-pass filters for my nearby neighbors and now I am clean on their TV receivers.

what about stereo equipment?

Ham signals can easily get into stereo gear and can cause a lot of problems. Again, the cause is simple. The equipment is mostly solid-state, operates at low signal levels and has no shielding or filtering against strong nearby radio transmissions! The stereo market is very competitive and everything that can be done to save a *penny is* done, and this includes omission of any RFI suppression circuits.

table 1. List of stations registered for operation on 10.1 and 10.15 MHz.

kHz	mode	call	location	kW	remarks
10,100.0	RTTY	RUZU	Molodezhnaya Base, Antarctica		Meteo
100.5	CW	KNY28	Washington, DC, U.S.A.	1.0	Algerian Embassy
102.0	RTTY	YIF25	Baghdad, Iraq	2.5	PTT
103.0	"	YIE99	" "	2.5	INA
103.3	ISB	WWL20	San Juan, PR, U.S.A.	2.0	Telcom
105.0	RTTY	RKA79	Moscow, U.S.S.R.	20.0	TASS
105.0	"	STL52	Khartoum, Sudan	5.0	SUNA
113.0	"	FJY2	Port-aux-Francais, Kerguelen Is.	1.0	Meteo/TFC
114.7	ISB	TTZ	N'Djamena, Chad	6.0	Telcom/TFC
115.0	CW	8PX	Barbados, Barbados	0.2	TFC
115.0	FAX	BAF4	Beijing, P.R. China		Meteo
116.5	RTTY	5NK33	Kano, Nigeria	3.5	Meteo
118.0	USB	RG124	Moscow, U.S.S.R.	15.0	R. Moscow Feeder
118.5	RTTY	OEM70	Vienna, Austria	5.0	Meteo
118.7	"	STK	Khartoum, Sudan		Aero
120.0	"	HMR59	Pyongyang, North Korea		KCNA
122.0	"	AWC	Calcutta, India	2.5	Aero
123.1	CW	CSP40	Guarda, Portugal		Air Force
125.0	RTTY	ETD3	Addis Ababa, Ethiopia	2.5	Aero
125.0	"	OLG3	Prague, Czechoslovakia	30.0	TFC
126.0	"	DKZ	Berlin, German D.R.		DP
127.5	"	NGD	McMurdo Base, Antarctica	15.0	USN
128.0	ISB	JBE30	Tokyo, Japan	10.0	TFC
130.0	RTTY	NAA	Colter, ME, U.S.A.	15.0	USN
130.0	"	YIF29	Baghdad, Iraq		INA
130.0	FAX	RBW48	Murmansk, U.S.S.R.	20.0	Meteo
132.0	RTTY	TNL55	Brazzaville, Congo	1.5	Aero
133.0	"	J3R			UNID
135.0	ISB	IRH31	Rome, Italy	10.0	Telcom
136.6	CW/USB	-	Emergency Nets of U.S.A.		USCG
137.0	RTTY	TNL97	Brazzaville, Congo	1.5	Meteo
140.0	RTTY/CW	RUZU	Molodezhnaya Base, Antarctica		Meteo/TFC
140.0	RTTY	UBJ	Baku, U.S.S.R.		Meteo
140.0	CW	UGE2	Bellingshausen Base, Antarctica		TFC
143.0	RTTY	A9C	Bahrain, Bahrain		Aero
144.9	"	HBO20	Geneva, Switzerland	10.0	
145.0	"	JAE30	Japan		
147.0	USB	TUP	Abidjan, Ivory Coast	2.0	Telcom
150.0	RTTY	SUA246	Cairo, Egypt	10.0	MENA

Filtering and bypassing interconnecting leads usually solves this vexing problem, but the subject is too complex to cover in this short article. A recommended publication tells the whole story and gives you plenty of good data on RFI problems in general.[3]

two new, good books for Radio Amateurs

It is always refreshing to find publications of interest to Radio Amateurs. Prentice-Hall publishers (Englewood Cliffs, New Jersey) are entering this field with two new books by Doug DeMaw, W1FB. Doug, as you know, is the Senior Technical Editor of *QST* magazine.

Doug's first book is *Ferromagnetic-Core Design & Application Handbook*.[4] This hardcover, 256-page book covers design and use of inductors using toroids, rods and pot cores for ferrite and powered-iron materials.

Ferromagnetic materials are common today in receiver and transmitter circuits, power supplies, and antenna baluns, but the use and theory of these interesting devices are shroud-

ed in mystery for most Amateurs. Doug's book tells the whole story in simple words and terms and covers circuit design and application from A to Z. The information is invaluable and the book should be in every ham's library. Of great help is the section covering available cores and rods. Now when some article specifies a core with a red dot on it, or Q-2 material, I'll know what the author is talking about!

Doug's second book is *Practical RF Design Manual*,[4] a hardcover book of 246 pages. This is a gold mine of information for the experimenter who designs and builds his own equipment, or for the inquisitive Amateur who wants to know how his gear works. It covers the important circuitry used in today's exciters, receivers and transceivers. It contains in-depth coverage that general-coverage handbooks can't afford to include, mainly because of a restriction on the total number of pages in the publication.

The book has an impressive section on receiver dynamic range, and equally handy sections on frequency control systems, very useful to the home constructor. It also includes more data on small- and large-signal amplifiers than I have ever seen in one publication. Best of all, the book is written in language the average Amateur can understand.

the 10-MHz Amateur band

I have monitored the 10-MHz band almost daily during the past year. Over 50 countries permit Amateur operation on this band and such good DXers as FB8WG and VK9YC operate regularly in the 10-MHz region. By the date this is in print, the band should be open to American Amateurs.

It is interesting to compare those who should be in this region against those who are actually there. **Table 1** shows the official International Telecommunications list of stations registered for operation between 10.1 and 10.15 MHz. Careful monitoring of the band during the summer showed that most of these stations really weren't there, with the exception of NAA's powerful RTTY signal at 10.130 MHz. Most of the rest of the ITU-registered stations were conspicuous by their absence. In their place was a rag-tag group of intruders who have less legal reason for being there than do Radio Amateurs.

the new Radio Handbook

The twenty-second edition of the *Radio Handbook* (Howard W. Sams Co., publisher) has been on the market for a few months.[5] I have edited this book since the fourteenth edition (1956). It is interesting to note the tremendous advance made in Amateur Radio in 26 years!

The new edition is primarily devoted to solid-state equipment, sideband and linear amplifiers — the latter hardly mentioned or known in 1956. And in addition, counters, phase-locked oscillators, fm, satellite communication, moonbounce, slowscan TV, RTTY, color TV, spread-spectrum transmission, keyboards, keyers, solid-state amplifiers, and low noise reception are covered in the twenty-second edition of the *Radio Handbook*.

ham radio

references

1. A copy of the J.W. Miller catalog can be obtained free by writing to: Bill Courtney, J.W. Miller Division, Bell Industries, Box 5825, Compton, California 90224.
2. A copy of the B&W catalog can be obtained free by writing Elmer Bush, Barker and Williamson, 10 Canal St., Bristol, Pennsylvania 19007.
3. RFI is no problem if you don't have it, but many headaches if you do. Recommended reading on this subject is the *Interference Handbook*, by William Nelson, WA6FQG, former RFI investigator, Southern California Edison Company. The Ham Radio Bookstore has this *Handbook*, or it may be ordered from Radio Publications, Box 149, Wilton, Connecticut 06897.
4. These books are available from the Ham Radio's Bookstore for $28.95 each plus $2.00 shipping and handling.
5. Available from the Ham Radio's Bookstore, Greenville, New Hampshire 03048 for $34.95 plus $2.00 shipping and handling.

the ham notebook

Ten-Tec 645 ultramatic keyer mods

I run my station on battery 100 percent of the time, and am always looking for a way to trim a few milliamps of drain. I became concerned with the appetite of my Ten-Tec 645 Ultramatic Keyer the first time I put a meter in series and discovered a quiescent drain of over 300 mA. After opening the case and pulling the board, I burned my thumb on the two 68 ohm 2-watt resistors used to drop the 12 Vdc line.

I removed R_{17}, R_{18}, and D_3, a 5.6 volt zener diode. In this same space I mounted an LM340 T-5 three-terminal regulator and a small heatsink. The regulator mounted easily after I drilled a single hole for the middle (ground) wire. I could then put the keyer back in its original shape without a lot of telltale holes in the board.

Because this regulator is some distance from the 12 volt supply, I used an external bypass capacitor of 0.22 μF on the input terminal of the regulator. Mount it as close as possible to the regulator. The 0.1 μF capacitor recommended for the output is provided by C_9 already in place.

Next socket the ICs and substitute some 7400 LS chips for the original 7400s. I did this on a trial and error basis and found it worked for IC-1, IC-2, IC-3 but *not* IC-4 and IC-5. Thus, you need two 74LS00 (IC 1 and 2) and one 74LS10 (IC-3). A check showed 120 mA quiescent, almost a two-thirds reduction! Not enough to fool with if you are using commercial ac, but enough to make a difference for extended battery operation.

Adding an extra key jack in parallel with the output of the 645 keyer allows you to use a straight key. Mount the phono jack on the rear panel and bypass with a 0.01 μF capacitor.

The low speed range of the keyer can be expanded by changing the value of R_1 from 4.7K to 8.2K. Unless you really need 50 WPM, it is much nicer to be able to accurately adjust in the 10-20 WPM range; the top end is still above 40 WPM.

A stereo (three conductor) jack can be added to the rear panel to allow the use of the 645 paddles to feed a memory keyer (such as the Autek MK-1). Use a shorting jack and the paddles return to the 645 when the plug is removed. This saves getting used to new paddles for contest work.

Gil Frey, Jr., K4JST

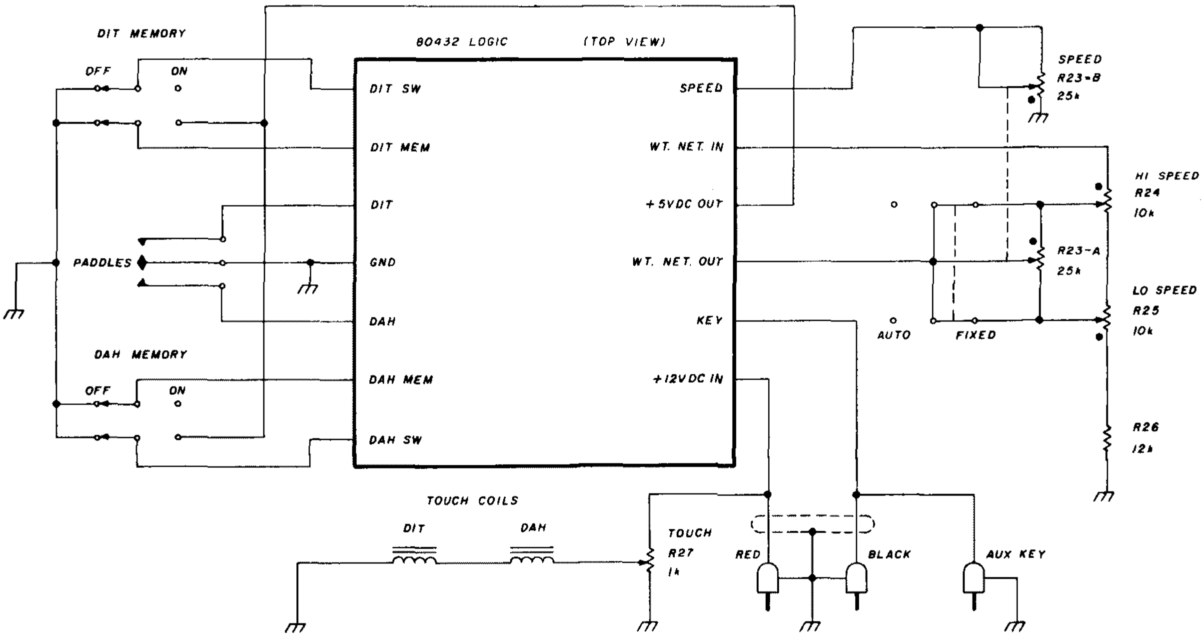


fig. 1. Logic board.

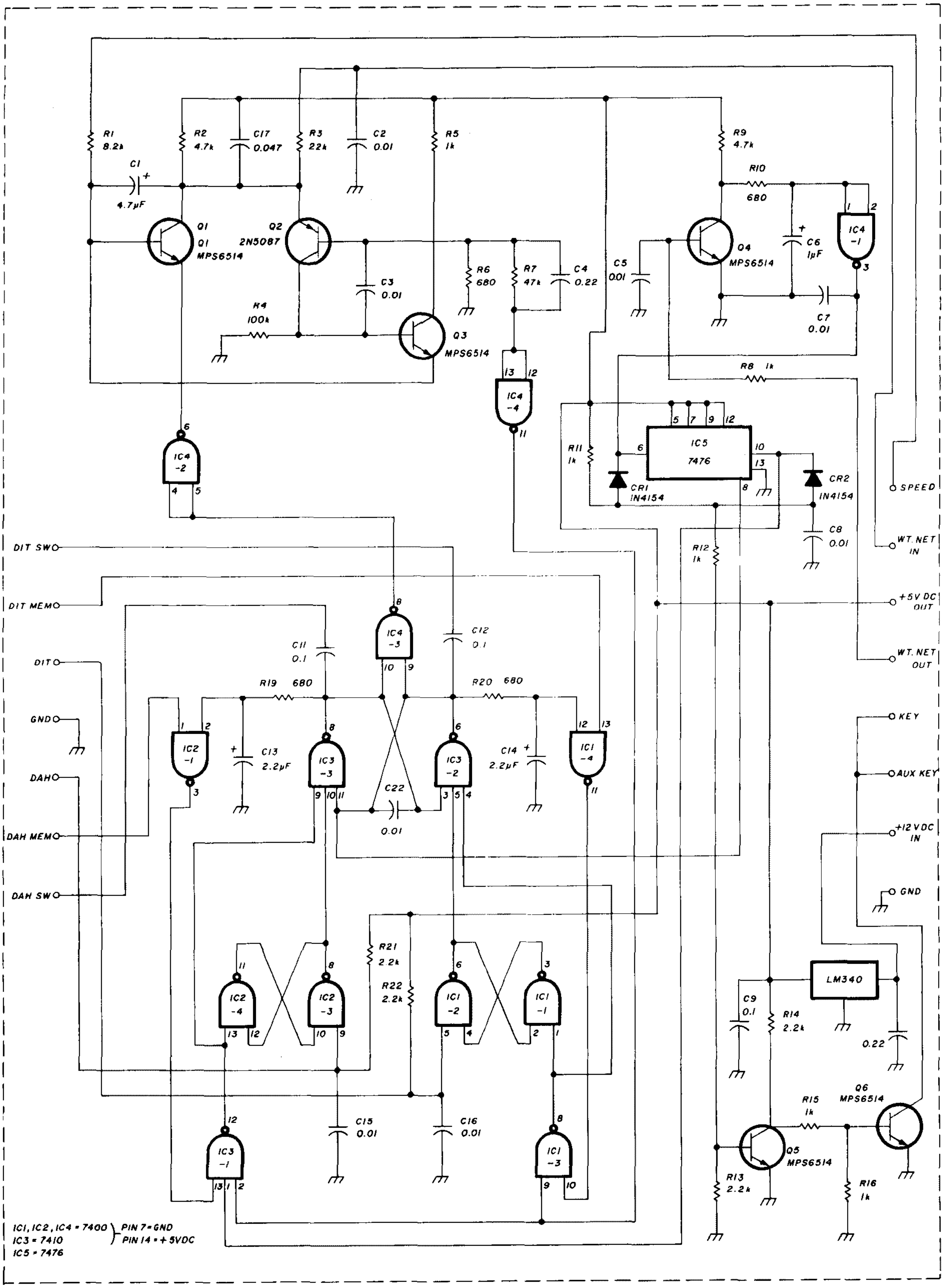


fig. 2. Wiring block diagram.

receiver dynamic range

Defining and deriving a popular and important specification

Today's communications receiver is expected to detect and extract information from signals of varying levels in a crowded spectrum. Earlier designs were concerned primarily with good sensitivity and selectivity. New requirements call for a high degree of rejection of spurious products produced by nonlinear interaction of many strong signals, sometimes far removed from the receiving frequency.

One method of determining the quality of receiver performance is to specify both an upper and lower signal-handling power limit, that is, a spurious-free dynamic range. To establish performance criteria requires a knowledge of the receiver's sensitivity (MDS), its third-order intercept point (defined later), system noise figure, and i-f bandwidth. Let's first define dynamic range.

Dynamic range is the power range over which a device such as a radio receiver provides useful operation. The upper limit of the dynamic range (P_u) is limited by the level of two equal input signals that create a third-order intermodulation product, which is equal in amplitude to the Minimum-Detectable-Signal (MDS)* level. The MDS is considered as the lower limit (P_L) of the dynamic range, and is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth. The minimum detectable signal can be found through eq. 1.

$$P_{L(dBm)} = MDS_{(dBm)} = -171\ dBm^{\dagger} + NF_{(dB)} + 10 \log (BW)_{IF} \qquad \text{eq. 1}$$

Where: MDS is the low-power limit of dynamic range in dBm.
NF is system noise figure in dB.
BW_{IF} is i-f bandwidth in Hz.
P_L is lower power limit of dynamic range in dBm.

The upper limit of the dynamic range can then be expressed by eq. 2.

$$P_{u(dBm)} = 1/3\,(MDS + 2\,IP) = 1/3\,(-171\,(dBm) + NF\,(dB) + 10 \log BW_{IF\,(Hz)}) + 2/3\,IP\,(dBm) \qquad \text{eq. 2}$$

Where: P_U is the upper power limit of the dynamic range in dBm.
IP is receiver's third order input intercept point in dBm.

By combining the two equations, we can find eq. 3 for the total spurious-free dynamic range:

$$\begin{aligned} SFDR\,(dBm) &= P_U\,(dBm) - P_L\,(dBm) \qquad \text{eq. 3}\\ &= 1/3\,(MDS + 2\,IP) - MDS\\ &= 2/3\,(IP - MDS)\\ &= 2/3(IP(dBm) - NF(dB) - 10 \log BW_{IF\,(Hz)} + 171\,(dBm))\end{aligned}$$

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*Sometimes referred to as the noise floor.
†$KTB + 3\,dB = -171\,dBm$.

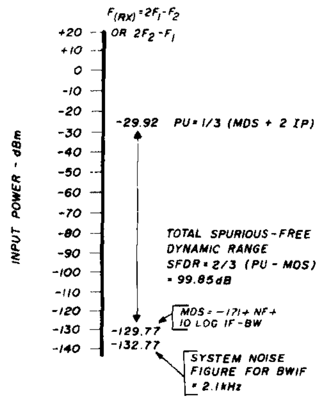

fig. 1. Determining the dynamic range of a receiver with a noise figure of 8 dB, an i-f bandwidth of 2.1 kHz, and an input intercept point of +20 dBm.

Where: *SFDR* is the spurious free dynamic range.

This equation shows that the dynamic range is *directly proportional to the intercept point (IP) and* inversely proportional to the noise figure (NF), and i-f bandwidth (BW_{IF}).

We can then say that the dynamic range improves with lower noise figures, narrower i-f bandwidths and higher intercept points.

The following example shows a practical application for the dynamic-range formula. Assume a typical high-performance receiver with a noise figure of 8 dB, an i-f bandwidth of 2.1 kHz and an input intercept point of +20 dBm. Substituting these quantities in eq. **3** yields:

$$SFDR = 2/3\,(+20\,dBm - 8\,dB - 10\log 2100\,Hz + 171\,dBm) = 99.85\,dB.$$

$$SFDR = 99.85\,dB.$$

The total distribution of this number can best be understood by examining the graph in **fig. 1**. We know that the total spurious-free dynamic range (SFDR) for our receiver is 99.85 dB, but what is not known is where this range fits in the total picture of the receiver's sensitivity, and once this is found, what this range means from a practical performance point of view. We had previously determined that the lower limit of the dynamic range is given by the Minimum Detectable Signal (MDS). If, using **eq. 1** for our example, we find the lower limit of the receiver's dynamic range to be −129.77 dBm.

$$MDS = -171 + 8 + 10\log 2100 = -129.77\,dBm.$$

We can then say that the system's noise level for an i-f bandwidth of 2.1 kHz is 3 dB below this number, or −132.7 dBm (MDS is defined as a signal 3 dB greater than the equivalent noise level for a specified i-f bandwidth).

Knowing the MDS, the IP (20 dBm) and with the help of eq. 2, we can determine the upper limit of our 99.85 dB dynamic range:

$$P_u = 1/3\,(-129.77 + 40) = -29.92\,dBm.$$

The same result would be obtained if we added the total dynamic range of 99.85 dB to the MDS:

$$P_u = 99.85 + (-129.77) = -29.92\,dBm.$$

This last procedure could be used to verify the validity of eq. 2.

If these numbers are plotted as shown in **fig. 1**, we can conclude that the receiver in our example will perform undisturbed for all input signals varying from approximately −30 dBm to −130 dBm, with the receiver tuned to a third-order intermodulation product produced by two strong signals equal in amplitude and differing in frequency from each other. The amplitude of these signals, as well as the difference frequency (ΔF), were represented in our example by the +20 dBm input-intercept point. In practice, this quantity is a function of the output intercept of all non-linear elements, such *as mixers, amplifiers, etc.*, involved in the design of the receiver, as we will see next.

intercept method

Fig. 2 shows the intercept method, used as an evaluation method for the strong-signal handling capability of a radio receiver. In practice, the dynamic range of a receiver is measured with the setup shown in **figs. 3** and **4**.

First, the MDS is found as shown in **fig. 3**. The MDS is measured as the power necessary at genera-

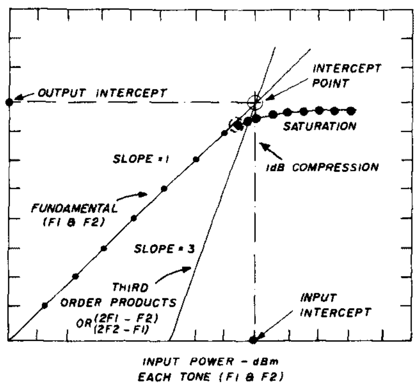

fig. 2. Determining output and input intercepts of a radio receiver.

tor G (expressed in dB), to produce a 3 dB increase in audio output over the noise level of the receiver. The MDS is specified for a given i-f bandwidth. The greatest bandwidth should be used for a worst-case analysis.

Knowing the MDS, the setup in **fig. 4** can be used to actually find the output intercept, and with this information, the input intercept can be plotted as shown in **fig. 2**.

To find the output intercept point, the outputs of the two signal generators (G_1 and G_2) are combined in a hybrid combiner. The output of the combiner (which now contains a two tone signal) is applied through a calibrated step attenuator to the receiver.

The two generators are usually 10 kHz apart, with the receiver tuned to 2F2-F1 or 2F1-F2, a third order product. The attenuator is then varied until the response of the receiver at the frequency of the third-order product is the same as that produced by the MDS found earlier. The performance is specified by measuring and plotting the output intercept as shown.

If the receiver is well designed, the desired output signal and the distortion product curve will intersect as high as possible, as shown in our example. This is the output intercept which describes the intermodulation response of the receiver.

The input intercept can also be plotted from the intercept point. This number can then be used to find the spurious-free dynamic range as previously discussed.

In conclusion, the receiver processes a weak signal in the presence of many adjacent strong signals. Because of the deficiencies in the design of the first mixer and the front end, if a preamplifier is used, the receiver may not be able to copy the weak signal, and it may be completely blocked out. The receiver's ability to perform under such conditions is expressed by the spurious-free dynamic range.

This article was adapted from the book *Radio Communications Receivers* by the author, published by TAB Books Inc. It is available from the Ham Radio Bookstore, Greenville, NH 03048, for $13.95 plus $2.50 shipping and handling.

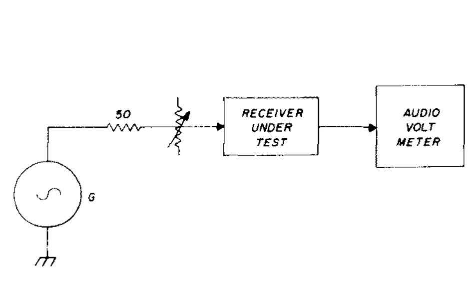

fig. 3. Set-up for measuring MDS.

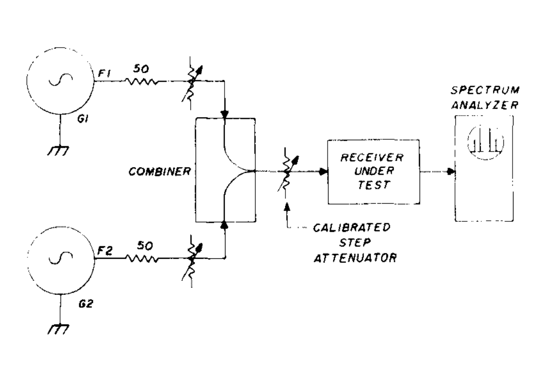

fig. 4. Set-up for measuring output intercept point. Input intercept can then be plotted and used in the dynamic-range formula.

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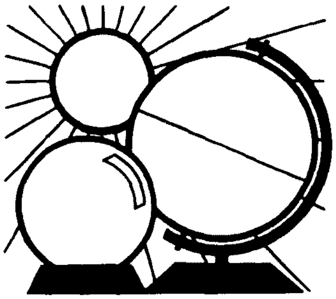
ham radio



DX FORECASTER

Garth Stonehocker, K0RYW

last-minute forecast

December is probably the best month for winter DX. The low signal absorption combined with high daytime MUFs result in excellent signals on the higher DX bands (10 and 20 meters). On the other end of the frequency spectrum, the long nights make for excellent DX on 40 through 160 meters.

Expect the 27-day solar maximum just at the end of November and again on the 23rd of December: consequently, the higher DX bands should be active the first week and the last week-and-a-half of the forecast period. The days in between should favor the lower frequency bands. December is traditionally one of the quietest insofar as geomagnetic disturbances are concerned, but the days of highest probability will be around the 9th, 18th, and 28th.

The winter solstice will take place on the 22nd at 0439 UT. A partial eclipse of the sun (74 percent obscured) will occur on the 15th across Europe, extreme northeast Africa, and west Asia, and on the 30th there will be a total eclipse of the moon across North America, Asia, and Australia. Lunar perigee will be on the 2nd at 1100 UT and the 30th at 2200 UT; by coincidence, full moon will be on the 1st and 30th.

The Geminid meteor shower, which reaches its peak on December 13th and 14th provides the richest and most reliable display of the year, with rates of 60 to 70 per hour (determined mainly by radio, because of the poor weather in December). Also, a smaller portion of the shower (15 to 20 per hour) is observed on December 22.

more on the radio-quality index

If you have talked Santa into bringing you a home computer for Christmas, you may want to use it to enhance your ham radio DX operating by programming a radio-quality index into it. A formula was given in the DX Forecaster column in the August, 1982, *ham radio*. Further programming and debugging help is given below.

I have divided the formula into three sections, a term and factors, and given representative values within the ranges of the variables. First is the seasonal term, θ, which is used as the power to which the solar flux, ϕ, is raised. This term is needed to increase quality in the summertime, probably representing increased signal strengths from sporadic-E layer propagation. It varies from 0.7375 in winter to 1 near summer solstice, as in the following table:

day	A 0.49315x	$\cos^2 A$	θ
1 (January)	0.49315	0.999925	0.7375
80 (March)	39.45200	0.59626	0.8435
172 (June)	84.82180	0.008215	0.9978

Day number x is the day of the year, starting with January 1 as 1. February 1 would be 32, and so on. Use trig identity, $\cos^2 A = \frac{1}{2}(1 + \cos 2A)$.

The radio flux factor, $\log (\sqrt[4]{\phi})^{\theta}$, is the log to base 10 of the fourth root of the radio flux number, right from WWV. The ϕ varies from about 65 to 400, and the value of this factor for three values of ϕ and the θ extremes of 1.0 and 0.7375 are as follows:

		factor value in	
ϕ	$\log \phi$	June	December
70	1.84510	0.461	0.340
150	2.17609	0.544	0.401
375	2.57403	0.643	0.475

The magnetic factor is $e^{-0.01A}$, where A is the magnetic number (estimate) for the day from WWV. The exponential function e^x is used. A table of representative values is as follows:

A	$-0.01A$	$e^{-0.01A}$
5	−0.05	0.9512
10	−0.10	0.9048
50	−0.50	0.6065
100	−1.00	0.3679

Finally, putting the factors all together with the 10-times factor and the +0.82 term to shift the scale to a 0 to 9 range of numbers, an overall example for March 21, 1982, (day 80) with solar flux of 150 and A of 10 is calculated as follows:

$$Q = 10\ \frac{0.8435}{4}\ (2.17609)(0.9048)$$

$$+ 0.82 = 4.15 + 0.82 = 4.97 \text{ or } 5$$

band-by-band summary

Ten, fifteen, and twenty meters will have DX from most areas of the world during daylight and into the evening almost every day. Long skip and one-long-hop trans-equatorial openings toward evening can be opportunities for new DX locations. Look for them during the few disturbed geomagnetic periods, otherwise watch for high solar flux days for ten and fifteen meter openings.

Forty, eighty, and one-sixty meters are the night DXer's bands. Excellent extended periods of long skip, albeit over shorter distances than on the higher bands, can make a cold winter night enjoyable. Low noise and quiet geomagnetic conditions generally result in pleasant operating this time of year. Happy Holidays, and lots of DX during the coming new year!

ham radio

WESTERN USA

DECEMBER

GMT	PST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
0000	4:00	10	20	15	15	15	10	10	15
0100	5:00	15	20	15	15	15	10	10	15
0200	0:00	15	20	15	15	15	10	10	15
0300	7:00	20	20	15	15	15	15	10	15
0400	8:00	—	40	20	15	15	15	15	20
0500	9:00	—	40	20	20	15	15	15	20
0000	10:00	—	—	20	20	20	20	15	20
0700	11:00	—	—	20	20	20	20	15	20
0000	12:00	—	—	20	20	20	20	20	40
0900	1:00	—	—	20	40	20	20	20	40
1000	2:00	—	—	—	40	20	40	—	40
1100	3:00	—	—	—	40	40	40	—	40
1200	4:00	—	—	—	—	40	40	40	40
1300	5:00	—	—	—	40	—	40	40	—
1400	6:00	—	20	—	20	—	40	—	—
1500	7:00	20	20	—	20	—	—	—	—
1000	8:00	20	20	20	15	—	40	20	—
1700	9:00	20	20	15	15	—	20	15	—
1800	10:00	20	15	15	15	—	15	15	—
1900	11:00	15	15	15	10	20	15	15	20
2000	12:00	15	15	10	10	20	10	15	15
2100	1:00	15	20	15*	15*	15	10	15	15
2200	2:00	15	20	15	15*	15	10	10	10
2300	3:00	10	20	15	15	15	10	10	10

MID USA

MST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN	CST
5:00	15	20	15	15	15	10	15	15	6:00
6:00	15	20	15	15	15	15	15	15	7:00
7:00	15	20	15	15	15	15	15	15	6:00
8:00	20	20	20	20	15	15	15	20	9:00
9:00	—	40	20	20	15	20	15	20	10:00
10:00	—	40	20	20	15	20	20	20	11:00
11:00	—	40	20	40	15	20	20	—	12:00
12:00	—	40	—	40	20	20	20	—	1:00
1:00	—	40	—	40	20	20	20	20	2:00
2:00	—	40	—	20	20	—	—	20	3:00
3:00	—	—	—	20	—	—	—	20	4:00
4:00	—	—	—	40	—	—	—	20	5:00
5:00	—	—	—	—	—	—	—	—	6:00
8:00	20	—	—	20	—	—	—	—	7:00
7:00	20	20	—	15	—	—	—	—	8:00
8:00	20	20	15	15	—	—	20	—	9:00
9:00	20	20	10	10	—	—	20	—	10:00
10:00	20	15	10	10	—	20	15	—	11:00
11:00	20	15	10	10	—	20	15	—	12:00
12:00	20	15	10	10	—	15	15	—	1:00
1:00	—	15	15	10	—	10	15	20	2:00
2:00	—	20	15	15	15	10	10	15*	3:00
3:00	—	20	15	15	15	10	10	15*	4:00
4:00	—	20	15	15	15	15*	10	15	5:00

EASTERN USA

EST	N ASIA FAR EAST	NE EUROPE	E S. AFRICA	SE CARIBBEAN S. AMERICA	S ANTARCTICA	SW NEW ZEALAND	W OCEANIA AUSTRALIA	NW JAPAN
7:00	15	20	15	15	15	15	10	15
8:00	15	20	20*	20	15	15	15	15
9:00	15	20	20	20	15	15	15	20
10:00	—	20	20	20	15	15	15	20
11:00	—	20	20	20	15	15	20	20
12:00	—	40	20	20	15	20	20	20
1:00	—	40	20	20	20	20	20	20
2:00	20	40	20	40	20	20	20	20
3:00	20	40	40	40	20	20	20	—
4:00	—	40	40	40	—	20	20	—
5:00	—	—	40	40	—	40	—	—
6:00	—	—	—	40	—	—	—	—
7:00	—	—	—	20	—	—	—	—
8:00	—	—	15	20	—	—	—	—
9:00	20	—	10	15	—	—	—	—
10:00	20	15	10	10	—	—	—	—
11:00	15	10	10	10	—	20	15	—
12:00	15	10	10	10	—	20	15	—
1:00	15	10	10	10	—	20	15	—
2:00	—	10	10	10	—	15	15	—
3:00	—	10	10	10	15	15	15	20
4:00	—	15	10	15	15	10	15	20
5:00	—	15	15	15	15	10	10	15
8:00	—	15	15	15	15	10	10	15

Look at next higher band for possible openings.

is it stolen?

How to avoid being burnt by more than rf

Willie Hambone earned the name "Bargain Willie" at his local radio club for good reason. He always knew the price of the latest radio equipment, and had a feeling for what a seller would expect when it was offered at a ham flea market. He was, of course, a veteran of the Dayton Hamvention; after Willie had made the pilgrimage to Dayton for several years, his acquaintances wondered what equipment he *didn't* have. But when the annual local hamfest — one of the largest in the state — came, Willie was there.

This time Willie's eagle eye fastened on the latest model Modzilla 870, complete with power supply, Modzilla mike, and 870-RV remote VFO. No manual; but the seller assured Willie that since it was a current model, he would have no trouble getting one from the U.S. distributor for $10, and he'd shave that off the price. Price? Well, the current market price was $1,350 — but since the seller was about to take a job working for an oil exploration company in South America, and needed some cash to pay his wife's hospital bill, he'd take $675 — exactly half price — less the $10 to buy a manual.

Not everybody goes to a hamfest with $665 in his pocket, but Willie always said that cash talks, and his hot little hands soon pulled that bargain price out of his wallet, gave it to the seller, and proceeded to carry his new acquisition to his car. The rest of the hamfest was anti-climactic for Willie; he could hardly wait to get his new gear home and on the air. Since it was a class piece of equipment, he decided he ought to check with another ham in town who had a Modzilla 870; and after his friend had reviewed the tune-up procedure with him over the telephone, Willie plugged it in for the smoke test.

It worked beautifully. The path to Europe was open on 15, and it was no trouble to work Gs and DLs with the barefoot rig, one station after another. During the next few days, Willie checked the rig out on other bands, and found it even brought in QSOs on 160. In short, he was delighted, both with the rig and with his bargain. He was tempted to forget about the instruction manual, lack of which had shaved $10 off the price — but when he thought that *someday* he'd sell the rig for a later model, he wrote a letter to Modzilla's U.S. distributor in La Squinta, California, enclosing $10 for a manual, carefully noting the serial number of the equipment so that he would get the proper edition for his new 870.

Willie's joy seemed unlimited. The heatsink on his 870 hardly had a chance to cool down, so happily did Willie describe his bargain far and wide during the next few weeks. Then, on Saturday afternoon, it happened.

the problem arises

The doorbell rang, and with some disgust, Willie — who was home alone — answered. The caller turned out to be a Deputy Sheriff with a folded sheet of paper in his hand. "Willie Hambone?" he inquired.

"That's me," Willie acknowledged.

"Mr. Hambone," the deputy went on, "I have a search warrant signed by Judge Green of the County Court, authorizing me to search your premises for pieces of stolen radio equipment. They are called a Modzilla Model 870 and an 870-RV; and I have a picture of this type of equipment. If you have it here and want to show it to me, fine; otherwise, my partner and I will have to go through your house, room by room."

Willie felt the floor sinking beneath him. "Look, officer, I have a Modzilla 870, and you're welcome to look at it; but I paid good money for it. I didn't steal it from anybody; I bought it, and it's mine!"

They proceeded to Willie's shack, where Willie announced, "Here it is. These are produced by the

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thousands. Maybe a few get stolen, but I paid for this one."

"You may have paid for it, Mr. Hambone, but if this equipment carries serial number 89-6634, you are in possession of stolen property. May I look at the serial number on the back?"

Willie already knew the number; his heart sank. His request for an instruction manual, giving the serial number . . . of what was a stolen rig!

It didn't take the deputy long to check the number. But if Willie felt bad about losing $665, he felt even worse after the deputy's next announcement:

"Mr. Hambone, you are under arrest, charged with receiving and concealing stolen property of a value sufficient to constitute a felony. I must advise you that you are not required to make any statement; any statement you make can be used against you in court; you are entitled to counsel; and if you cannot afford counsel, an attorney will be provided for you. You must come with me to the County Jail, where you will be booked, and you will be allowed to call an attorney from there."

Willie's bargain had evaporated. In fact, so had his world.

what happened to Willie

Willie hired a competent lawyer, whose services were not inexpensive. At a preliminary hearing, his lawyer raised the defense that Willie had no knowledge the transceiver was stolen; that such knowledge is an essential element of the crime of receiving stolen property. The judge agreed and dismissed the charge, but his remarks to Willie are worth noting:

"Mr. Hambone, I am dismissing the charge of receiving stolen property, although I hesitate to do so. You are an Amateur Radio operator, and I feel quite sure you knew the true value of this equipment at the time you bought it. Such knowledge of value would permit this court to draw an inference that you sensed the equipment was stolen. Since you have no criminal record, I am dismissing the complaint; but if you are ever again found to have stolen equipment in your possession, the court will take a different attitude."

Some bargain, that transceiver! Willie not only lost the $665 he had paid for the Modzilla 870; he paid his attorney's fee, and in local ham circles, he was now known as "the ham who has been had."

The unhappy situation fictionalized here may well have happened, at least in many details. We all know expensive Amateur Radio equipment is stolen from time to time. The elaborate high-frequency mobile installation is almost a thing of the past. VHF and some HF equipment is now made small enough that the owner can unplug the major component — a transceiver — and carry it in his briefcase.

The development of the ARRL insurance program, to a considerable extent, is the result of growing radio equipment theft. This article is not designed to tell you how to avoid theft of your equipment; it is designed to suggest ways in which you may avoid the purchase of *stolen* equipment.

Traditionally, physical possession is considered one indication of ownership. While it may be an *indication* of ownership, it does not prove your title to the property. So, where do you obtain some proof of title? As to new merchandise — and let us take a typical transceiver purchased from an established dealer — you will receive a paid invoice, identifying the goods by make, model, and serial number. Considering the importance of equipment warranties, every buyer should insist that a serial number be included on his invoice. This invoice is evidence of a contract of sale, and by law, a contract of sale implies a warranty of good title to the merchandise sold, and that the transfer is a rightful one.[1]

At any flea market, the majority of vendors are not merchants regularly dealing in Amateur Radio equipment. More often, they are individuals with usable gear they no longer want or need, which they want to convert into money or other ham gear. We normally do not expect such a casual seller to furnish ownership documentation; it is unusual when he furnishes a receipt for the goods you purchase. If a seller will accept your check in payment, you may note on the back, "In payment for Johnson Invader Serial No. 116628," but this only shows what the check paid for; it does nothing to prove that the seller was the owner.

proof of ownership

It is not too much to ask a seller of any major item of equipment to furnish some evidence the goods are his. Every ham should staple his purchase invoice onto the back of the instruction manual for reference at the time it is sold. There are tactful ways to ask for title evidence; you will not make friends by saying "How do I know it isn't stolen?" but you can easily say, "Do you have an invoice to show where this gear was purchased?"

Not everyone keeps sales invoices. Sometimes we want to forget how much money went into one piece of gear! But there is no reason why a Bill of Sale cannot be given, preferably in a form which will identify both buyer and seller, say where the seller obtained the equipment, state the selling price, contain a warranty of title in all cases, a warranty against liens, and a warranty of condition whenever condition is vital to the sale. A suggested form for a Bill of Sale is shown in **fig. 1**. It can easily be reproduced in quantity to use at hamfests and flea markets; perhaps the club

BILL OF SALE

The Seller, ____
(Name of Seller)

____ in consideration
(Address of Seller)

of the price of $ ______________________________ paid to him, receipt of which is

acknowledged, hereby sells to ____
(Name of Purchaser)

____
(Address of Purchaser)

the following equipment:

______________	______________	______________
(Quantity)	(Description)	(Serial No.)

originally purchased from ____

Seller represents and warrants that he is the owner of the equipment sold, and no other person has any interest in it, or lien upon it by way of an unterminated Financing Statement, or otherwise. As to the condition of the equipment, Seller makes the following representations:

(Check one below which applies)

☐ 1. The equipment is in good working condition.

☐ 2. The equipment is sold "as is", and Seller makes no representation as to its performance.

☐ 3. The equipment requires repairs (other than normal alignment) in order to meet the performance specifications of the manufacturer.

Witness:

______________________ ______________________
(Signature of Seller)

Date of Sale: ______________________

fig. 1. Sample *Bill of Sale* form.

sponsoring the affair can have them printed, and make them available at printing cost.

effect of a Bill of Sale

Between seller and buyer, the Bill of Sale is clear proof that the seller has transferred whatever ownership he had to the buyer. In most cases, possession of a Bill of Sale by the buyer precludes any criminal intent on his part, should the gear prove to be stolen; without criminal intent, you would not end up with a charge of receiving stolen property as suggested in poor Willie's example.

If the seller has valid title to the property, the Bill of Sale effectively transfers it to the purchaser. But if the seller does not have good title to the property, the purchaser acquires no more ownership than the seller had. It is certainly worthwhile to protect yourself against criminal liability by asking for and receiving a Bill of Sale. Would you *want to* make a deal with someone who refuses to give a *Bill* of Sale?

possible liens

Much new radio equipment is bought on credit. Some radio supply houses reputedly make more money on their credit operations than on the sale of the gear itself, which can occur when a supplier does the financing rather than using Master Charge, VISA, etc. If the gear has been financed by the purchaser, the seller or the financing agency has probably filed what is called a Financing Statement. When a Financing Statement has been recorded, the party extending credit may have rights to the goods after the date of *recording* which are legally superior to those of the purchaser. If you acquire an expensive piece of relatively new gear from someone who has a reputation for buying everything on credit, you would be wise to check with your County Clerk or Register to see if there is the lien of a Financing Statement recorded against what you plan to buy. A Bill of Sale should include a representation that no such lien exists.

some common-sense conclusions

No one wants his own equipment stolen, nor does anyone want to help thieves of Amateur Radio equipment by furnishing them a market. We can all help shrink the stolen equipment market by retaining our purchase documents, complete with serial numbers. When buying used gear, insist on evidence of ownership; ask for purchase records, but take a Bill of Sale in any event. The Bill of Sale, if properly drawn up, will show that you purchased the equipment in good faith, will identify the seller, and can also serve as a warranty of the condition of the equipment. Taking into account the present cost of equipment — either new or good used gear — insisting on a Bill of Sale is a wise precaution!

references

1. *Uniform Commercial Code*, Section 2-312.

ham radio

NEW products

Heil EQ200 mike equalizer

We always thought we had good audio from our transmitter. No one ever complained about garbled speech or hard-to-understand transmission. Granted, we have had people tell us we sound like Demosthenese, the Greek orator who practiced with stones in his mouth . . . that was before Bob Heil sent us his latest product, the EC200 microphone equalizer.

Bob Heil is well-known throughout the audio field as an expert on sound reproduction. Besides being a professional organist, he is in constant demand by music groups from rock bands to Philharmonic orchestras. He knows his audio. In a conversation with Bob, he stated that the most misunderstood and neglected part of any ham station is the microphone/audio circuitry. Sure, there have been compressors, clippers, and whatever. But they do more to compound the problems of poor audio than solve them.

With this in mind, Bob determined to apply his professional expertise to solve the problem. Looking through manufacturers specifications, Bob found most modern transmitters and transceivers have filter networks that limit audio input to the 300-3,000 Hz range. But most *microphones* are designed to cover a much broader range of frequencies, since they are used in services as diversified as stereophonic reproduction to paging services. The broader response of the microphone will be transmitted, and this will unnecessarily broaden your output.

The solution he came up with is the EQ200. The basic circuit is two 741 op amps (cm 1458). One-half of the first IC is used as a preamplifier and a transformer to provide proper impedance matching. The other half of the IC is used as a peaking lowpass active filter. The second IC is used as a shelving highpass filter and a line summing amplifier.

There are three controls on the front panel of the unit. The mike preamp gain may be adjusted from 0 to +20 dB. Heil advises that this be set so the microphone will not overload or clip. The LO control is used as a boost and cut control. Boost refers to increasing the level, cut reduces the level. The boost and cut is ±12 dB. The low filter is centered at 490 Hz. The HI control is also a boost and cut, with the filter centered at 2800 Hz.

As mentioned before, most microphones used today were not designed for ham use; their audio response is usually much greater than is necessary. Since all microphones are different, there is no universal setting. Heil has some recommended settings, but it best to set the processor through a trial-and-error process. Luckily, we have a friend who received an EQ200, so we tested and set our processors together. It was interesting to actually hear how the high and low tones can be emphasized and deemphasized to create a truly pure-sounding signal.

The only problem we found was that we chewed up batteries. That can be remedied easily by installing a 9 Vdc supply or adding a low drain LED to remind you the unit is on. This is more of an inconvenience than a problem. Bob Heil tells us a newer model will incorporate these changes.*

Finally, Bob provides some helpful hints about how to use the microphone properly, such as keeping adequate spacing between mouth and microphone and making sure your operating room is not full of echoes.†

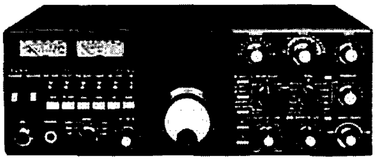
The EQ200 is a nice item to have between your rig and microphone. Price is $49.95 for the basic unit. For more information, contact Heil Sound, Box 26, Marissa, Illinois 62257.

*For those who own EQ200s, changing the input resistors from 10K to 100K should solve the problem of excessive power drain.

†As an added feature, the EQ200 can be modified to work as a two-tone generator for SSB tuning and testing. A parts kit is available from Heil Sound for an additional $7.00.

new high-frequency equipment line

Yaesu Electronics Corporation is pleased to announce the availability of the new FT-102 line of high-frequency equipment. The FT-102 transceiver uses an all-new transmitter section, featuring three 6146B final tubes for extremely low distortion. In addition to VOX and an rf clipping-type speech processor, the FT-102 transmit audio may be adjusted for optimum response to the operator's voice.



The FT-102 receiver uses JFET components in the front end for wide dynamic range. A number of filter options are available, with wide/narrow filter selection independent of the mode switch. Audio peak filtering for CW, audio shaping for all modes, and an i-f notch filter provide intelligence recovery. The noise blanker is highly effective against the Woodpecker and pulse noises.

Equipped for SSB and CW operation, the FT-102 option list includes an a-m/fm module for activating those modes. Other accessories for the FT-102 are the FV-102DM synthesized VFO, the SP-102 speaker with audio filter, the SP-102P speaker/patch, and the FC-102 1.2-kw an-

tenna tuner with optional remote antenna selector.

For further details, contact Yaesu Electronics Corp., P.O. Box 49, Paramount, California 90723.

electronic parts by mail

A new, free catalog lists over 1500 electronic items which can be ordered through the mail. Parts are high quality, no rejects or seconds. Large line of semiconductors, LED displays, lamps, connectors, sockets, headers, jumpers, switches, meters, amplifiers, generators, etc. Some items are available in kit form or assembled. All items can be shipped immediately from stock.

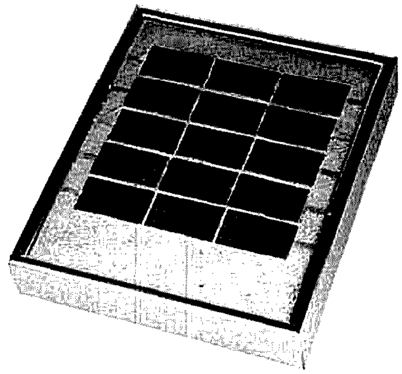
For more information, contact Sintec Company, Drawer Q, Milford, New Jersey 08848; telephone 1-800-526-5960 (New Jersey residents dial 201-996-4093).

photovoltaic battery charger

The Phaeton II Photovoltaic Battery Charger manufactured by International Solar Products Corporation of Durham, North Carolina, produces 4.8 volts of direct current power at 240 milliamps in peak sunlight. Four AA cells, two C cells, and two D cells can be charged with the unit. Batteries are fully recharged in 14 to 16 hours of sunshine.

Phaeton II measures 6 × 7 inches and weighs less than two pounds. It is constructed with anodized gold or silver frame, heavy-duty aluminum battery cradles and the same silicone covering used to protect the solar cells on orbiting communication satellites. The unit contains no plastic parts.

The manufacturer states the average consumer could spend as much as $100 per year on throw-away batteries to power portable radios, tape recorders, toys, games, flashlights,



cameras, and other electronic appliances found in many homes today. At $49.50, the Phaeton II can totally replace this annual cost after it pays for itself in the first 6 to 7 months of use.

The unit is available directly from the manufacturer, International Solar Products Corporation, 1105 W. Chapel Hill St., Durham, North Carolina 27701; telephone 919-489-6224.

frequency counter program

A cassette program that turns the Apple II computer into an audio frequency counter with an accuracy of 30 parts-per-million. You may consider this a rather expensive frequency counter, especially when it doesn't cover rf at all. However, it is aimed primarily at those experimenters who already have an Apple II computer.

This counter has a twist to it. Unlike most frequency counters, it does not gate the unknown for a fixed reference period. Rather it counts an approximately equal number of clock pulses over an exact (but arbitrary) multiple of whole cycles of the unknown. Then it calculates the frequency from this average, much as a period counter would. The result is that the full stated accuracy is achievable in less than two seconds, over the entire audio range. This means that in less than two seconds you can find out the frequency of your subaudible tone encoder to within 0.01 Hz. The counter can achieve even

NEW products

greater accuracy if you have a little patience. It also keeps a running average of the last N (default is 50) samples. If fewer than N have been taken, it will average them. The result is accuracy approaching 1 PPM.

Although the Apple's time base (which is the reference for this program) isn't calibrated or compensated, it is crystal controlled and therefore relatively stable over short periods once it has temperature stabilized. Included is a procedure (need only your cassette recorder, microphone, and a color TV) to calibrate it in software, using the 15734.26 Hz horizontal oscillator frequency of a color TV receiver. This signal is of course locked to the station it is receiving, which, if a network program is being viewed, is in turn locked to a cesium 3.579545 MHz reference at the network.

A copy of the cassette costs $15. For more information and dealer prices, contact Wilton Helm, WA6GQO, 827 Vinton Court, Thousand Oaks, California 91360.

220 MHz H.T. amplifier

Mirage Communications Equipment, Inc., announces the release of its new 220-MHz amplifier. The C22 solid-state all-mode 220 to 255 MHz amplifier has the same famous five-year warranty (one year on rf power transistors) as all Mirage products.

The C22 has many features, including bias as a linear amplifier IE: fm, SSB, CW; it can be keyed with as little as 300 mW; 2 watts in with 20 watts out; and dc power 13.6 Vdc at 3 amps (full output).

For additional information, contact Mirage Communications Equipment, Inc., P.O. Box 1393, Gilroy, California 95020; telephone 408-847-1857.

micro computer pollution control

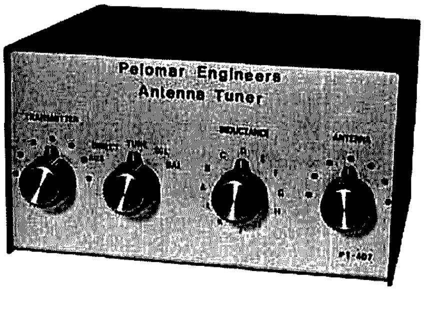
Power-line electrical noise, hash, and spikes often cause erratic computer operation. In addition, severe spikes from lightning or heavy machinery may damage expensive hardware. Many systems create their own pollution. Disks and printers often create enough electrical interference to disrupt an entire program. Nearby electronic equipment is affected as well.

Electronic Specialists' recently-announced Magnum Isolator Model ISO-17 is designed to control severe electrical pollution. Incorporating heavy duty spike/surge suppression, the Magnum Isolator features four individually quad-Pi filtered ac sockets. Equipment interactions are eliminated and disruptive/damaging power line pollution is controlled. The Magnum Isolator will control pollution for an 1875-watt load. Each socket can handle a 1000-watt load. Price, $181.95.

For more information, contact Electronic Specialists, Inc., 171 South Main Street, P.O. Box 389, Natick, Massachusetts 01760; telephone 617-655-1532.

300-watt antenna tuner

Palomar Engineers introduces the new PT-407 antenna tuner. The PT-407 is a general-purpose tuner for 1.8-30 MHz, for matching antennas



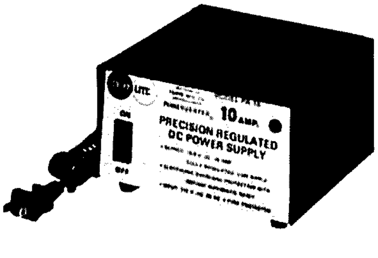
fed with coaxial or open wire lines, single wire, or mobile antennas. The 300-watt power rating makes it just right for most transceivers. The PT-

407 is an efficient tuner with a large, airwound coil, a large balun for open-wire feed, and with ceramic insulation throughout. It is housed in an 8 × 4 × 7-inch aluminum cabinet with brushed aluminum control panel and black vinyl cover. All controls are on the front panel. Coaxial connectors are SO-239. Porcelain feedthrough insulators are used for balanced line and single wire inputs.

The PT-407 Antenna Tuner sells for $149.95. For further information write to Palomar Engineers, 1924-F W. Mission Road, Escondido, California 92025; telephone 714-747-3343.

regulated dc power supply

The precision-regulated dc power supply from Tripp-Lite converts 120 Vac into 13.8 Vdc. It allows users to operate dc mobile equipment on ac



home power, and it saves money, as this unit is inexpensive and eliminates the need for buying ac equipment.

Features include solid-state integrated circuits for precise regulation; filter insuring low noise operation; current limiting electronic foldback for automatic overcurrent protection; heavy duty power transformer for complete line isolation; ripple voltage from 0 to full load is only 0.1 volts maximum; on/off indicator light and on/off switch on face-plate; UL listed ac cord and plug type SPT-2.

For more information, contact Tripp-Lite, 500 N. Orleans, Chicago, Illinois 60610.

Hamtronics® kits

The R76 VHF fm receiver kit is a new version of the R75 receiver for 10 meters, 6 meters, 2 meters, 220 MHz, or the adjacent commercial bands. It features a very low noise front end, pump-resistant squelch with hysteresis to lock onto fading signals, onboard volume and squelch controls for easy wiring, and fixed i-f filters for easy alignment. It has also been reduced in size — now only 3¼ × 4 inches (8.25 × 10.16 cm). It is available in two selectivity options, starting at $84.95.

The model R451 UHF receiver kit includes the features in the R76 kit as well as automatic frequency control to lock onto drifting transmit signals. Kits are available with various options starting at $94.95.

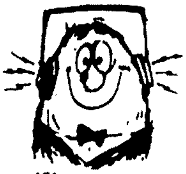
Hamtronics® new line of low-noise amplifiers resembles the popular P30 and P432 receiver preamps, but the circuit is new. The LNA 28, LNA 50, LNA 144, LNA 220, and LNA 432 units are optimized for lowest noise figure at the ham bands, but they can also be used on adjacent commercial bands. The LNA 432 also provides very good gain and noise figures for UHF TV signals and the new 800 MHz commercial band: 0.5 dB at 28 and 50 MHz, 0.6 dB at 144 MHz, 0.7 dB at 220 MHz, and 0.95 dB at 432 MHz. Gain runs from 33 dB at 28 and 50 MHz to 17 dB at 432 MHz. The price is $39.95 for the VHF units and $44.95 for the UHF unit.

The Shuttle receiver kit, a special version of the Hamtronics R110-450 UHF a-m aircraft receiver to listen to the space shuttle, is now available off the shelf for $94.95.

For further information, contact Hamtronics, Inc., 65-V Moul Road, Hilton, New York 14468-9535; telephone 716-392-9430.

5/8 antenna for handhelds

Centurion has added a new model to their line of heavy-duty telescoping antennas. It is a full-length 5/8-wave



NEW products

radiator providing increased efficiency and range for handheld radios.

Designated Style F, the new antenna for VHF frequency bands from 118-174 MHz is fitted with a BNC connector.

For more information, contact

Centurion International, P.O. Box 82846, Lincoln, Nebraska 68501-2846; telephone 402-467-4491.

special keyboard

Pipo Communications has just announced a specially designed keyboard compatible with the Collins KWM-380 high-frequency radio. The new sixteen-button keyboard is color-coordinated and has the fourth row buttons marked to indicate their function. This will facilitate ease of operation by eliminating the need to memorize what the buttons do. The keyboard sells for $20 and has a frame available for $3.

For more information or to order, please contact Pipo Communications, P.O. Box 3435, Hollywood, California 90028; telephone 213-852-1515.

6-meter transceiver

ICOM has announced the IC-505, a fully synthesized multimode transceiver covering 50 to 54 MHz (option), USB, LSB, and CW on fm. It uses an internal battery pack (9 C-size batteries), and puts out three watts of rf power when run on its batteries, or ten watts when connected to an ex-

ternal 13.6 volt dc source. Low power is 0.5 watts.

Features include an LCD frequency display for low battery consumption, provision for internal memory back-up, dual VFOs, five memories plus a call channel, memory scan, program scan, sideband squelch, LCD annunciators for VFO, scan, memory channel, call and split, and split frequency operation.

For more information, contact ICOM America, Inc., 2112 116th Avenue, N.E., Bellevue, Washington 98004; telephone 206-454-8155.

GaAs FET VHF/UHF amplifiers

Lunar Electronics announces a line of narrow-band tuned receiving preamplifiers for the VHF and UHF communities. Typical specifications exceed previously available receiving preamplifiers by up to ten times in performance. Exhibiting very high gain at VHF, typically 22-24 dB, moderate gain at UHF, typically 16 dB, plus a very low noise figure, typically 0.3-0.4 dB at VHF and 0.5-0.6 dB at UHF land mobile frequencies, these units are also well suited to high rf environments, exhibiting 1 dB compression power levels of +10 dBm or more. The good gain, coupled with very low noise figure, effectively reduces a typical repeater receiver sensitivity to that of ambient limitations. Improvements in receiver performance have been consistently reported by users at 6-10 dB in a typical repeater installation between the duplexer and receiver input.

Units are built to customer's specified frequency, but do exhibit a typical bandwidth of 5 percent CF with little degradation in performance. Dc input is well filtered and regulated, which allows accepting any dc voltage between 12 and 28 volts, drain approximately 35 mA. VHF connector options include BNC, SMA, N in and out; UHF connector options are SMA, N in and out, with SMA in BNC out the standard option. SMA to RG-58 connectors are included as option for UHF units. Frequencies are available from as low as 15 MHz to the 800 MHz land mobile bands.

For more information, contact Lunar Electronics, 2775 Kurtz Street, Suite 11, San Diego, California 92110; telephone 714-299-9740.

FOR SALE: Popular Kenwood TS-520S w/CW filter, VOX and CW never used. Rig used very little and in mint condition. Original carton and manual $500. Morris Shishcoll, W6IRP, 613 S. Breed St., Los Angeles, CA 90023. (213) 262-4598.

SAVE MONEY on Rubber Stamps. Catalog plus discount coupon. Send 25¢. Hastings, Box 1951-HR, Pine Bluff, AR 71613.

CHEAP, QUALITY ANTENNAS! Di-poles. "The Di-pole" report covers construction, materials, setting up. Plus: frequency, SWR/Power loss and effective radiated power charts. Only $3.00/copy. Cheque or MO to HBE Publishing, Box 13226, Kanata, Ontario K2K-1X4.

WANTED: Buy or swap Model 28 paper winders (LPW 300). Top prices paid for complete units or parts. Call or write Van, W2DLT. In NJ 800-272-1331, outside NJ 800-526-3662. Box 217, Berkeley Hts., NJ 07922.

R390A SSB ADAPTER — excellent SSB, RTTY. No receiver modifications needed $25. K8EYU/7, 963 Birch Bay Lynden Rd., Lynden, WA 98264. (206) 354-5884.

MANUALS for most ham gear made 1937/1970. Send $1.00 for 18 page "Manual List", postpaid. HI-MANUALS, Box R602, Council Bluffs, Iowa 51502.

SATELLITE TELEVISION — Howard/Coleman boards to build your own receiver. For more information write: Robert Coleman, Rt. 3, Box 58-AHR, Travelers Rest, SC 29690.

WANTED: Schematics-Rider, Sams or other early publications. Scaramella, P.O. Box 1, Woonsocket, RI 02895-0001.

WANTED: Early Hallicrafter "Skyriders" and "Super Skyriders" with silver panels, also "Skyrider Commercial", early transmitters such as HT-1, HT-2, HT-8, and other Hallicrafter gear, parts, accessories, manuals. Chuck Dachis, WD5EOG, The Hallicrafter Collector, 4500 Russell Drive, Austin, Texas 78745.

TELETYPE PARTS WANTED: Any quantity, any models, highest prices paid. In NJ 800-272-1331, outside NJ 800-526-3662. Van, W2DLT, Box 217, Berkeley Hts., NJ 07922.

SATELLITE TELEVISION: Discount prices on all major TVRO items. Communications Consultants. (501) 452-3149.

HAM RADIO REPAIR, experienced, reasonable, commercial licensed. Robert Hall Electronics, P.O. Box 8363, San Francisco, CA 94128. W6BSH. (408) 292-6000.

RUBBER STAMPS: 3 lines $3.25 PPD. Send check or MO to G.L. Pierce, 5521 Birkdale Way, San Diego, CA 92117. SASE brings information.

D & V RADIO PARTS — Variable capacitors, miniductors, toroids, etc. Write for flyer, stamp please. 12805 W. Sarle, Freeland, Michigan 48623.

WANTED: New or used MS and coaxial connectors, synchros, tubes, components, military surplus equipment. Bill Williams, PO #7057, Norfolk, VA 23509.

VERY in-ter-est-ing! Next 5 issues $2. Ham Trader "Yellow Sheets", POB356, Wheaton, IL 60187.

CB TO 10 METER PROFESSIONALS: Your rig or buy ours — AM/FM/SSB/CW. Certified Communications, 4138 So. Ferris, Fremont, Michigan 49412; (616) 924-4561.

HAMS FOR CHRIST — Reach other Hams with a Gospel Tract sure to please. Clyde Stanfield, WA6HEG, 1570 N. Albright, Upland, CA 91786.

KT5B Multi-Band dipole 160-80M (WARC) $59.95. 2KW plus center connector w/SO239 $8.50. Kilo-Tec, P.O. Box 1001, Oak View, CA 93022. (805) 646-9645.

MOTOROLA ALL SOLID-STATE MOTRAN RADIOS, Model X43LSN-2170, four frequency, transmit 150 MC (30W), receive 450 MC. Will operate in Ham Bands. No modification required. Large stock available. $150.00 each. Omni Communications. Call (312) 852-0738.

MOTOROLA VHF (2 meters) U43 Motran, 4 channel all solid state. Omni Communications. Call (312) 852-0738.

Coming Events

ACTIVITIES

"Places to go..."

ILLINOIS: Wheaton Community Radio Amateurs Hamfest will be held February 6, 1983 at Arlington Park Race Track EXPO Center, Arlington Heights, Illinois. Free Flea Market tables and plenty of floor space. Large commercial area including computer section. For general info call W9JTO at 311-231-9524. Clear paved parking.

Awards. Tickets $3.00 at entrance, $2.50 in advance. Send SASE to WCRA, P.O. Box QSL, Wheaton, IL 60187. Talk-in on 146.01/61 and 146.94. Doors open 8 AM. Be There! — KA9KDC.

INDIANA — SOUTH BEND: Hamfest Swap & Shop, January 2, 1982, first Sunday after New Year's Day at Century Center downtown on U.S. 33 Oneway North between St. Joseph Bank Building and river. Industrial History Museum in same building. Carpeted half acre room. Tables $3 each. Four lane highways to door from all directions. Talk-in freq: 52-52, 99-39, 93-33, 78-18, 69-09, 145.43, 145.29.

MINNESOTA: The annual Handi-Ham Winter Hamfest, Saturday, December 4, at the Eagles Club, Faribault. Registration at 9 AM. Handi-Ham equipment auction, noon dinner, program and prize drawing. Talk-in on 19/79. For more information: Don Franz, WØFIT, 1114 Frank Avenue, Albert Lea, Minnesota 56007.

VIRGINIA: Richmond Frostfest '83. The annual winter Ham Radio and Computer Show will be held Sunday, January 16 at the State Fairgrounds, Richmond. General admission: $4.00. All indoor flea market and commercial exhibits. Major prizes in HF and VHF equipment and a minicomputer. Sponsored by the Richmond Amateur Telecommunications Society, P.O. Box 1070, Richmond, VA 23208.

WOULDN'T IT BE GREAT? To pick a winner for "Amateur of the Year" at the Dayton Hamvention and get Free Tickets too. Write for details: Hamvention, P.O. Box 44, Dayton, Ohio 45401, attention awards. Do it now!

OPERATING EVENTS

"Things to do..."

DECEMBER 4: The Everglades ARC will operate W4SVI, 1300 UTC, December 4 and 2200 UTC December 5 to celebrate the 35th anniversary of the dedication of Everglades National Park. Frequencies: 10 kHz up from lower edges of 40 to 10 meter General phone bands and 146.52 MHz. Certificates for QSL and large SASE to: W4SVI, c/o Dick Dowst, Everglades ARC, 14511 S.W. 287th Street, Leisure City, FL 33033.

DECEMBER 17: The Switzerland of Ohio ARES will operate a Christmas special event station at Jerusalem, Ohio, under the call N8DLJ, December 17, 18, 19 from 1600 to 2200Z each day. Frequencies: First 10 kHz of General phone portion of each band and the first 10 kHz of the Novice bands as propagation permits.

DECEMBER 7: KCØFW plans to operate from St. Kitts (VP2K) December 7 to 13. All bands 160-10 phone and CW. Special attention to working Europeans and JA's.

DECEMBER 1-31: The BBC is celebrating the 50th anniversary of the official start of the Empire Service (now renamed the External Service). To commemorate this, the Ariel Radio Group has obtained special call signs. Stations will be GB2BBC, GB3BBC, GB8BBC, Central London; G3BBC, West London and GB4BBC, Caversham near Reading. Also other BBC Club Stations will participate. 80m to 2m with maximum activity around December 19. Main operating mode SSB on HF.

DECEMBER: The Borealis ARC will present the Worked All North Pole Certificate to anyone working a minimum of three BARC members. Operating time 0400-0900Z, 30 kc up from lower edge of Novice and General bands. For certificate send call signs, dates worked and $2.00 to: Borealis ARC, c/o Wendell Keller, SR Box 80343, Fairbanks, AK 99701.

DECEMBER 9: The Triple States Radio Amateur Club will operate from Bethlehem, West Virginia, December 9 - December 12 from 1400 to 2300 UTC daily. Frequencies: for WD8DDU/8 will be 7.275, 14.325, 21.415 and 28.550 MHz on SSB and 7.110, 14.075, 21.110 and 28.110 MHz on CW. For a special holiday certificate for contacts SASE to TSRAC, 26 Maple Lane, Bethlehem, Wheeling, WV 26003.

DECEMBER 18: The Sandy River ARC, Farmington, Maine, will operate KA1CNG, Saturday, December 18, 1500Z to Sunday, December 19, 2100Z to celebrate Chester Greenwood Day. Also mobile from the Chester Greenwood Day Parade and related activities Tuesday, *December 21, 1400Z to 2100Z. Frequencies: 5 to 10 kHz* from bottom of General band edges and 3940 kHz. Certificate for your QSL card and two first-class stamps to KA1CNG, 5 Franklin Ave., Farmington, Maine 04938.

DECEMBER 4: The Argonne Amateur Radio Club plans to operate the club's memorial station, W9QVE, to commemorate the 40th anniversary of the first controlled nuclear chain reaction experiment conducted at Alonzo Stagg field on the University of Chicago campus, from 1500 GMT through 2400 GMT December 5. Frequencies: 20 kHz up from lower edge of General portion of bands 80 to 10m, phone and CW.

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